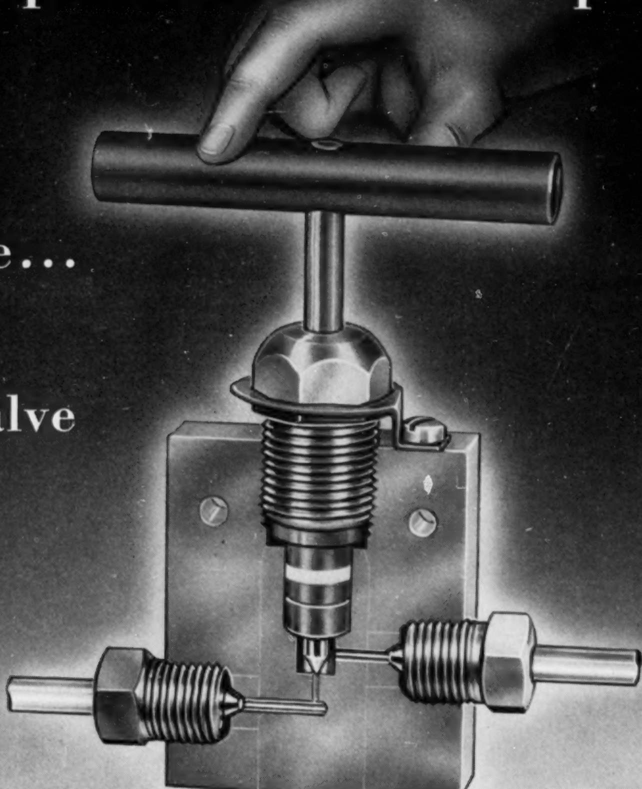
R/E RESEARCH & ENGINEERING

FOR RESEARCH & DEVELOPMENT MANAGEMENT

March

Finger-Tip Operation at 30,000 p.s.i.?

Of Course... With This Autoclave Valve



Another example of the continuous effort to improve the operation of high pressure equipment . . . .

Simplicity of design combines with rugged, precision construction to give you a 30,000 p.s.i. valve with "Finger Tip" ease of operation. This valve is widely used for reactions at all pressures up to and including 30,000 p.s.i. The gland nut is made of aluminum bronze which, of course, has a low coefficient of friction. Other materials can be furnished if desired. All threads in the stem and gland nuts are up above the packing—thus protected from material passing through the valve. Standard packing is Teflon but other materials are available—for example, a special high temperature packing for temperatures up to 1000°F. The locking device is of non-rusting, stainless steel. Bulletin 555 gives further detailed information. Write for it.

SPECIALISTS IN LABORATORY AND PILOT PLANT HIGH PRESSURE EQUIPMENT

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FOR MORE INFORMATION CIRCLE 111 ON PAGE 48.

INDIANA
PERMANENT MAGNET
DESIGN INFORMATION

published for industrial and consumer product engineers and designers

HOW PERMANENT IS A PERMANENT MAGNET?

Permanent magnets *are* permanent. Proof of permanence is substantiated by many practical applications over long periods of years.

The continued accuracy of some of the most exacting scientific electrical measuring instruments, or of the familiar house-type, watt-hour meter depends upon a permanent magnet.

The speedometer in your car, the magneto in your power lawn mower, or your wife's magnetic knife rack in the kitchen may be consigned to the junk pile in time because of mechanical failure or obsolescence .. but definitely not because of magnetic failure.

There is a common belief.. which is incorrect.. that a permanent magnet supports its external magnetic field by dissipating some of its *internal* magnetic energy. This definitely is not the case.

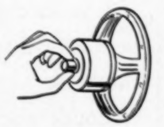
Adverse Factors on Remanent Magnetism. The magnetism of a permanent magnet can be adversely affected by any one, or a combination of, the following:

Elevated Temperatures can cause very appreciable initial losses in magnetism, up to complete demagnetization, even though metallurgical properties are not affected.

External Magnetic Fields from electro-coils, high electrical currents, or even other permanent magnets can partially or completely demagnetize the permanent magnet, and obviously, if the field is sufficiently strong, completely reverse the polarity.

Contact with Ferromagnetic Material by a permanent magnet in such a way that the normal internal field pattern is distorted can adversely affect the remanent magnetism. This is an important condition to avoid in the handling of magnetized magnets.

Changes in the Magnetic Circuit such as to produce a larger air gap than that on which it was initially magnetized, will reduce the strength of the magnet instantly and it is not recovered by reassembly to the original gap. A typical radio loud-speaker magnet, if removed from its associated steel circuit, then reassembled without remagnetizing, may lose as much as two thirds of its initial strength.



Vibration and Shock have little effect in most applications.

In all of these cases where only the remanent magnetism has been affected, losses can be recovered by remagnetization.

This article is a condensed version of a recently published feature article carrying the same title. Reprints of the full length article are available on request.

For assistance in designing the most efficient magnet for your product, consult our design engineers—without obligation, of course.

Magnetic Materials Exhibit at IRE Radio Engineering Show

Members of the magnetic materials design and application engineering staff of Indiana Steel Products Company will man the company's exhibit at the forthcoming IRE Radio Engineering Show in New York, Monday, March 19 through Thursday, March 22.

The exhibit, located in Booths 2 and 4 at Kingsbridge Palace, will feature a full line of permanent magnets including Cast Alnico .. Sintered Alnico .. Indox Ceramic Magnets .. and Cunife.

New manual discusses selection of permanent magnet materials

This newly published, 12-page manual entitled, "Permanent Magnet Materials and Their Selection," discusses physical and magnetic characteristics and the applications of Cast Alnico Magnets (Grades I, II, III, IV, V, VI, XII); Sintered Magnets (Alnico II, IV, V, VI, Indalloy and Indox I); Ductile Magnets (Cunico and Cunife I) and Formed Magnets (Chromium and Cobalt).

Also included is a selector-type chart which lists magnetic characteristics, design factors, material characteristics, and manufacturing methods and limitations of the various magnetic materials. In addition, special sections present a "Glossary of Magnetic Terms" and a list of magnetic "Symbols."

Copies of this publication are available on request. Ask for Manual 5-Q-3 on your company letterhead.

THE INDIANA STEEL PRODUCTS COMPANY
Valparaiso, Indiana
WORLD'S LARGEST MANUFACTURER OF PERMANENT MAGNETS

INDIANA PERMANENT MAGNETS

FOR MORE INFORMATION CIRCLE 112 ON PAGE 48.

RESEARCH & ENGINEERING

THE MAGAZINE OF RESEARCH & DEVELOPMENT MANAGEME

MARCH, 1956 VOLUME II — NO. 3 — SECTIO

FEATURES

DEPARTMENTS

THIS MONTH'S CONTRIBUTORS

ISRAEL KATZ
Cornell University

Israel Katz, Associate Professor of Ther Engineering at Cornell, teaches courses combustion engines, aircraft powerplant sign and automatic control. A consult to the General Electric Advanced Electr ics Center, he recently directed Proj GEMS there during a leave from Corn

JOHN RIVOIRE
Westvaco Mineral Products Division
Food Machinery & Chemical Corp.

John Rivoire, Manager of Market Resea for Westvaco Mineral Products Divis brings broad experience in government business to bear on operating a program industrial economics. He is complet work on his doctoral dissertation at Fo ham University.

RESEARCH & ENGINEERING

WILLIAM H. RELYEA, JR. *Publisher*

EDITORIAL STAFF

HAROLD G. BUCHBINDER • *Editor*
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GRETA LAREDO • *Editorial Assistant*
MARTHA MOFFETT • *Editorial Assistant*
MARTHA KNOWLES • *Assistant to the Publisher*
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CONTRIBUTING EDITORS

ROBERT BROTHERSTON • JAMES M. BEVERIDGE
MERRITT A. WILLIAMSON

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GArfield 1-3846

ARDEN H. PARKES
The Menne Co., 1127 Wilshire Blvd., Los Angeles 7, Calif.
MUtual 4191

ADVERTISING PRODUCTION

RAYMOND H. STOKES—*Assistant Advertising Manager*

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R/E Marks

MANAGEMENT MANHUNT

Recruiting of engineers and scientists for the primary field of research, development and design has received so much publicity over the past few years that an equally important recruitment problem has been almost completely overshadowed: the current manhunt for mature engineers with managerial abilities. The shortage of engineering managerial talent is less obvious because the means employed for its alleviation are more subtle.

Companies in need of engineering vice-presidents, chief engineers, research directors and scientists with managerial functions do not normally advertise openly—if at all. On one hand, open ads may tend to upset line engineers with premature indications of a change in hierarchy; and if ads indicate a need for many top engineering managers, stockholders may react in an unfriendly manner. On the other hand, engineers at the managerial level will not usually answer blind ads for fear they may be applying for their own jobs.

The general consensus among management counselors whose function is to recruit top-notch engineering managers is that higher-level executives find it difficult to make their desires to change jobs known, and at the same time, very few of them really know how to go about looking for new jobs without upsetting their current situations. These factors form a pattern that usually delays the right man from getting together with the right company.

While the total number of managerial jobs are appreciably less, the problem of finding the individual with the appropriate talents for a specific company is significantly greater. When hiring engineers, some companies operate on the philosophy that it pays to make errors in selection in preference to not having enough engineers on hand. Men who do not come up to par in engineering work can always be dropped to a high-class technician level. Because the recruitment cost and salaries of technicians are near that of the young engineer, the net loss is less. But at the managerial level, mistakes in selection can ruin a company.

Statistically, engineers and scientists come from the upper percentile of our intellectual resources. The problem of getting the most out of a team of engineers and scientists is quite different from obtaining the same objectives with production people. It's cases of mis-management in research development and design that has caused some companies with a high share of engineering brains to end up with more than their share of competition. In the past 10 years, a high percentage of new companies in R/D were formed by top-level engineers who became disatisfied with management policies of their superiors.

As an engineering manager, what can you do to attract and nurture appropriate personnel for managerial jobs generated by expansion as well as replacement? The current trend appears to center around in-company training for the more promising engineers. It is still easier to indoctrinate a qualified and experienced engineer in management techniques than it is to indoctrinate a good administrator in the fundamentals of engineering and science.

Training usually takes the form of subsidized courses at various business management schools supplemented by in-company training at regular periods. An important factor in favor of company training after some university background is that each company has problems peculiar to its own organic and functional set-up. Basic management principles are fine, but they must be interpreted to fit the individual needs of each company. For this reason, today's management man in R/D must not only be an engineer and an administrator, but lately a teacher of engineering management as well. Part of his responsibility now appears to include the up-grading of men who will ultimately fill managerial spots as they occur within his organization.

Proof of this trend is indicated by the fact that when in 1946 the National Industrial Conference Board attempted to measure and study executive training programs, there were not enough in existence for valid conclusions. In 1953, the American Management Association survey showed that 30 percent of the companies contacted, had definite programs, and in 1955, the percentage was up to 54 percent. No doubt the percentage would be higher if there were more companies well heeled in manpower and money. Most of the small and medium-sized companies that form the majority of our research and engineering efforts, simply cannot afford to pack their engineers off to school. Moreover, like the field of technology, familiarity with current philosophies and policies can lead to stratified behavior if the subject is not given continuous attention. Indeed, less indices of certainty exist in management than in engineering.

And this is where RESEARCH & ENGINEERING comes in—regardless of company size. In management, our editorial aim is to present surveys and articles that will enable you to keep up with the engineering management concepts and practices of your contemporaries, and to develop management skills and attitudes in the men that report to you. This month, in addition to shorter items in our Developments section, we offer an article on the "offbeat" personality in research and development, a survey on upgrading technicians and Merritt Williamson's monthly column on research administration. Taking what you need from these editorial pages this month and from our management pages in the months to follow may ease the management manhunt in your department and in your company.

Harold G. Buchbinder
Editor

Oppenheimer Says Scientists Wasted in Guided-Missile Program

Joining the wide-spread criticism of the Government's guided-missile program, J. Robert Oppenheimer stated that a great waste of technical talent existed in the guided-missile and nuclear-powered aircraft programs when he was last associated with them two years ago. The one-time head of the atom-bomb project also said that there were five to ten times as many scientists at Los Alamos developing the atomic bomb as were really necessary. Dr. Oppenheimer made these revelations in a general discussion of the state of physics in the nation at an informal press conference held before he addressed the American Institute of Physics in New York recently.

Much of the shortage of scientists in the nation can be ascribed to improper utilization, says Dr. Oppenheimer. However, he also feels that present methods of teaching physics could discourage students from pursuing the sciences. The way physics is taught today, there is no "beauty" or "joy" in the subject until the "golden years" of post-graduate study and apprenticeship. More students might be attracted to physics if we had more men who ". . . loved physics for itself . . ." rather than for what it can do, he added. These last sentiments were supported by Nobel Laureate I. I. Rabi in an address at the same meeting. Prof. Rabi said, "The aids to scientific education stem more from the fear that Russia will surpass us than from an interest in scientific knowledge and a concern for the general vigor and health of scientific endeavor and the preservation of a strong scientific tradition".

Hindsight Shows Errors

Looking back on the atomic bomb project, Dr. Oppenheimer can now say that it was over-staffed. However, he concedes that some of the superfluous talent may have given some necessary sparks to the program. As for the guided-missile projects, he thinks that scientists were being wasted in pursuing many nonsensical avenues of development. More early study is required to eliminate projects that are least likely to pay off. In response to a question as to the reason for this wasteful practice, Dr. Openheimer said, "We're rich!" He also deplored duplication in guided missile research and development between the various branches of the service. One means of stretching scientific manpower that he suggested is giving scientists more non-scientific assistants.

Scientists as Citizens

In his address, Dr. Oppenheimer also reiterated one of his favorite contentions: that scientists can not abdicate their rights as citizens and not talk about the import of their work.

"The labors of physicists in explanation and in prophecy are and cannot be ended; and there is no standing Joint Committee on the World's Salvation to which they can abdicate their concern. Yet by now the problem of living with the new dangers and the new hopes is where it belongs: with the public and its officers, the governments. Let us be sure that by our effort and our clarity we always keep it there."

Suspicion and Fear in the Atomic Age

When word came from Japan that the crew of a fishing boat had become the victims of atomic "fall-out", the world was shocked. Capitals seethed with talk that all H-bomb tests be banned. And the news stories added to the jitters of people everywhere who fear the harmful effects of nuclear radiation.

According to Nicholas Anton, president of Anton Electronics Laboratories, Inc., Brooklyn, the nuclear industry must act to offset the wave of unwarranted rumors and possible nuisance suits that plague those who would set up new atomic facilities. Speaking before a meeting of the New York section of the Instrument Society of America, Anton said that the problem facing the industry today is ". . . the protection of our nuclear facilities from the general public itself". He added that the situation becomes more acute with each report of a weapons test, every story on the effects of radiation poisoning and any public discussion on the future application of atomic energy.

Anton proposed that the industry take the initiative by telling the public what is being done to safeguard their health and welfare, with special emphasis on the outstanding safety record to date of both government and industrial atomic energy activities. He outlined a comprehensive program of radiological instrumentation which would meet the most rigid standards of public protection. This program would include a survey of the proposed plant or reactor site prior to construction of the facility and repeated testing after the installation had begun.

The "People's Capitalism"

The "People's Capitalism", says Philip D. Reed, board chairman of General Electric Company, is a system in which "all the people, not simply a privileged few, enjoy its fruits and benefits". Capitalism in the United States, he said "is quite different from the economic systems that go by the name of capitalism in other countries".

Research and development have been one of the mightiest factors in this country's dynamic capitalism. According to Mr. Reed, the nation's annual investment in organized research and development has quadrupled since pre-World War II days. "I believe this expenditure will continue to grow and it provides convincing assurance of a continuing flow of new knowledge, new ideas and new products that will stimulate both investment and demand in the years ahead," he added.

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"Transition Engineering" Helps Solve Manpower Shortage

Greater emphasis on "Transition Engineering", under which R/D and design engineers work together with a new product or system from its pre-prototype stage right into the production and testing stages, was urged on the nation's technical management by Dr. L. T. E. Thompson as a means of stretching available manpower. Now director of research for the Norden-Ketay Corporation, Dr. Thompson became interested in this technique as technical director of the Naval Ordnance Development and Test Center at Inyokern, Calif.

Although a first reaction might be that the valuable time of R/D engineers is being wasted, Dr. Thompson asserts that the technique actually results in speedier delivery, less cost and more productivity from technical personnel. The alternative frequently is the necessity for expensive redevelopment and redesign effort after the equipment has reached production. These continued changes in a system as it is adapted to production, at points in the development-production cycle too late for best results and without close consultation with the designers, waste time and lower effectiveness and reliability of the final product.

Thompson has continued work on the problems of transition between the several phases of a development-to-production cycle since he became head of the Norden Laboratories. He stated that there are really three transition periods. The first is involved with the important choices that have to be made near the end of the exploratory studies that should precede a full development effort. The second one is between prototype and product engineering. The third is between the evaluation (and operability) testing–final design and initial production. This managerial technique has been designed to exploit coordinating-group procedure to oversee the transition and to insure good "couplings" between the various stages in the evolution and production of a new system or device. Whenever work in any one stage has progressed to a point where the transition problems can be foreseen, personnel from the department that handles the next stage are added to the coordinating group.

The most important transition in Dr. Thompson's experience is the one between prototype and product engineering. At this stage, the very important operability tests under representative operating conditions must be conducted. The results are translated into changes in design that are expected to insure high reliability and ease of maintenance. To accomplish this result requires full collaboration, at the right times, of product engineers, development engineers and service operating personnel. Dr. Thompson emphasizes that handles the next stage are added to the coordinating is dealing with military or commercial systems.

Transition Engineering Not a New Concept

Many development organizations, endeavoring to improve communications between development engineers, designers, production men and customers, operate under a program similar to transition engineering. Some have a long record of success in the efficient handling of these transitions. It is generally believed that the interactions between research, development, design and production people, properly coupled, also produce more good ideas than can be had with the same groups shielded from each other. Good ideas are hard to get and the best possible stimulations are needed to encourage their evolution. Certainly a new idea for re-

search, an idea for a new approach, can come from a design or development engineer speculating about his own dilemmas, and correspondingly the influence of R/D thinking on operations thinking can often lead to better techniques and better systems.

Dr. Thompson is very much concerned with the shortage of technical manpower. Since the number of engineers and scientists can not be greatly increased in a short period, the alternative is making better use of the ones we have. Better transition engineering is one, at least partial, answer.

More Exploratory Effort

A second means for getting more out of our presently available technical manpower is to spend more effort in the exploratory stages of a design. "As well off as we are, comparing many other nations," says Dr. Thompson, "we can't try every alternative we can think of." Trying (nearly) everything has been too often justified as a means for not missing something good. We should spend more time eliminating the less likely avenues of development before serious design work on prototype hardware is reached. Thorough exploratory study is a natural method of selecting a smaller number of objectives for intensive development, certainly in the case of nations with limited resources. Now that we are rapidly reaching technical manpower ceilings, we must adopt the same practice, whether or not we are directly concerned with its inherent economy. It is undoubtedly true that, for a given total investment, we can get a greater return, probably in shorter time, by selecting hardware objectives only after completing thorough exploratory work whose results justify a development phase.

Growth Pattern of the Engineer: The Employer's Viewpoint

It may well be a "woman's world" as the recent motion picture would have us believe; but the engineers are running the distaffers a close second, and by next year it will probably be a dead heat.

But once they have pursued and won the engineer, employers frequently place "inhibitors" in his natural growth pattern. According to James H. Taylor, Director of Industrial Relations for the Proctor & Gamble Company, who recently addressed the Engineers Joint Council General Assembly in New York, some of these inhibitors include the following:

- We say we want him (the engineer) to have high technical competence, then we assign him to non-technical jobs, or to jobs which can be performed adequately by non-technical men.
- We say we want him to be creative and imaginative, then we have serious talks with him when he departs from the conventional or time-tested ways.
- We ask for a high degree of professionalization and interest in his field, then if he shows signs of supervisory skills we encourage him to direct his career toward production management responsibilities.
- We require from him identification and loyalty to management thinking, yet we isolate him from the area in which management concepts are evolved.
- We emphasize the importance of his contributions as a technical specialist, yet we pass out the kudos and the dollars to the engineer who becomes an administrator or a production supervisor.
- We again ask for and train to technical skill, yet we freely criticize him when he fails to handle, for instance, simple personnel problems for which he has received no training.

Taylor goes on to say that employees should recognize these fundamental conflicts as essential, necessary and ever-present. The problem is not to attempt to eliminate the conflict, but to handle the problem so that the unwanted negative attitudes will not develop.

The Lever That Moves the World

Perhaps the hand that rocks the cradle is about to be replaced by the lever that moves the world. According to Crawford H. Greenewalt, president of Du Pont, "the lever that moves our (industrial) world is . . . the lever of research and technology. It is that force, exercised today by thousands of men in hundreds of laboratories, that gives us our assurance of an ever brighter future".

Speaking before the annual dinner of the Delaware State Chamber of Commerce, Greenewalt went on to say that "Appraising research results quantitatively is not an easy job, and perhaps in the end one must simply take technology on faith . . . Over the last 30 years the Du Pont Company has invested in new construction somewhere between $20,000 and $25,000 for each man-hour spent by one of our research people in his laboratory. Since it takes about $20,000 of investment to create one job in industry, it might be said that the average research man during his 40-year working life would have created the basis for 40 jobs. And those are not temporary jobs since they represent . . . permanent additions to our industrial scene and to our people's prosperity".

Lead Time and Military Strength

Last month the controversy over appropriations for air research and development came to a head. Triggered by Sen. Harry M. Jackson's charge that the Soviets may win the race for the intercontinental ballistic missile, and superheated by the furor caused by Trevor Gardner's resignation as Assistant Air Force Secretary for R & D, the pressure built up to a climax—and it continues apace.

Rear Admiral Hyman G. Rickover, developer of the atomic submarine and one of our more outspoken public figures, had something to say on the subject that antedated the remarks of Jackson in the Senate and Hanson Baldwin in The New York Times (R/E, February 1956, page 13). According to Rickover, "lead time—the time which elapses between conception of a new idea, its development, and finally its fruition in the completed new article rolling from the production lines—is the factor which more than any other is likely to win the next war for the nation which succeeds in reducing it significantly below that of its competitor".

Rickover goes on to say that "lead time has always been a key factor in warfare, from the days when a man equipped his army with stone hatchets faster than his enemy. There has been a tremendous increase in technological complications in modern warfare, and lead time is now measured in years. In 1940, for example, about 17,000 man-hours were required to build a military fighter. Today the time for the same category of plane is 1,380,000 hours. In 1960, according to estimates, it will be 2,150,000 hours, and in spite of greatly increased productiveness of each man-hour".

Rickover concludes that "there can be no second place in a contest with Russia and that there will be no second chance if we lose. But if we lose, it will be largely by default. It will be because we have . . . wasted the marvelous ingenuity . . . of the American people in providing us with things which make life more pleasant but which really do not matter if they are bought at too high a cost".

Industrial Research: No Frosting on the Cake

Industrial research "is no longer like the frosting on a cake but is a critical element in the diet" of many companies and industries. Furthermore, research is neither "a creative activity carried out by rather sensitive and high-strung people", nor is it "a separate and distinct activity which can be looked upon somewhat like a capital investment". E. Duer Reeves, speaking before an American Management Association meeting on "Measuring Research Effectiveness", defined research as an "organized effort on the part of the company to provide itself with the technology it needs for its present and future operations".

He went on to say that research represents an operating division in its own right. In this role as a member of the company team research has definite responsibilities comparable to those of sales, manufacturing, purchasing and other functions.

Evaluating Research

The Esso Research and Engineering Company executive vice president thinks that "it is very important for a company to continually examine the effectiveness of its research effort . . . the first requirement for measuring (research effectiveness) is to have a clear understanding of just what it is and what it is trying to accomplish. Reeves enumerated the following "yardsticks" for evaluating research:

- Does the research organization know just what technology its company needs? Reeves says that "most people would think a company management completely unrealistic if it told its sales organization to go out and sell something with the thought that it would later decide whether it wanted to make it. Yet . . . many companies tell their research organizations to . . develop some new types of products or processes, after which they plan to decide whether the results are of any interest to the company."
- Is the research organization creating the needed technology? "Solving problems too soon for practical uses is a risky undertaking, since new elements or new tools later developed might indicate quite different and much simpler solutions. On the other hand, solving them too late is even worse, since if the technology is not ready when the company must act, the company will have to act without it. The objective of a well-integrated research effort is to have the technical information needed by the company flowing into it as it is needed."
- Is the research organization helping to get research results applied? "Using the results of research almost inevitably means doing things differently. Some people instinctively do not like to do things differently; some do not understand how the results can be applied; and some, even though they want to use the research, cannot do it without additional help. The major problem here is one of communications . . . all fronts in the research organization (must) arouse the interest of others in the company in research results."
- Are the research organization's operations efficient? "Industrial research is a lot like farming. The farmer, to

be successful, needs to use the best seeds he can get, and it would be . . . very poor judgment for him to try to economize by purchasing inferior seeds. The reason for this is that the money he has to spend for seeds is the least of his worries and most of his costs are determined by what he does with the seeds after he gets them. So it is with industrial research."

- Is research management an effective part of the executive team? "Ideally, I believe that the top executive group of a company should deal with research just as it deals with any other division. It should have a good understanding of the kinds of things a research organization can do and of the contributions it can make to the work of the company. As a part of its over-all plan of operations, it should incorporate research goals just as it does sales goals, and it should accept the executive in charge of research as a full member of the executive team."

Automation — What's Ahead?

Automation is a much maligned word. Labor has nothing kind to say about it; some executives see it only in terms of vast outlays of capital; and the public, knowing little about it, envisions it as some Artzybasheffian monster.

On the other side of the coin, George C. Ensign, director of research for the Elgin National Watch Company, has this to say: "We are deluding ourselves if we emphasize automation to the neglect of old-fashioned, sound engineering approaches" to production problems. Speaking before an Armour Research Foundation meeting on "Automation—A Conference for Executives", Ensign said that automation holds a "very bright" promise for the future but he added: "We may so complicate certain processes by automatizing that we may . . . add to capital investment and maintenance cost to the point where automation becomes unprofitable."

Last month the 33,000-member American Society of Tool Engineers (with one of the biggest stakes in automation) stepped in hoping to dispel some of the confusion.

According to a broad-scale study of automation made by ASTE, emphasis on automation will produce major influences on the design of future products. The survey shows that there will be a greater tendency toward standardization of components, even though there may be less standardization of assemblies.

ASTE further suggests that a new concept of "standards" will come in with automation. Rather than having fixed values, "standards" as applied to automated processes and equipment will have a range of values to permit reasonable future production variations without obsoleting automation equipment.

The biggest single factor which could greatly accelerate the broader adoption of automation in industry appears to be development of standardized units which would not have to be scrapped every time a model change occurred, but could be reused with only minor modifications or adjustments for a number of years. Added to this should be greater versatility in control and operating equipment to handle wider ranges of sizes or more complex operations than is now possible. Among developments in the direction of versatility would be automatic individual programming of production operations, including wider use of tape and punched-card controls on manufacturing equipment. The working out of simplified machine control panels would also permit greater flexibility of control.

Climax Bets On Metal Chemicals Boom

Metal chemicals are on the verge of an expanding market comparable to the boom in organics 50 years ago. Dr. John G. Dean's faith in this coming boom helps explain why Climax Molybdenum Company has retained this chemical and metallurgical consultant to help it capture a share of the growing metal chemicals market for moly compounds. Climax produces a major share of the moly mined in the world and owns the largest mineable reserve known—a whole mountain of ore.

Despite the fact that Dr. Dean has never worked with moly or its compounds before, Climax feels he will offer valuable advice on moly compound applications because of his wide experience in other metal compounds. Molybdenum in its compounds does resemble other metals, but more important, marketing techniques for moly compounds should be very similar to those of other metal compounds. The moly compounds are rarely directly competitive with other metal compounds in the chemical industry.

Major Use in Alloys

Although the major use for moly will undoubtedly remain in the alloying of steel, a field in which Dr. Dean will not advise Climax, he can offer important help on new catalytic uses for moly compounds. Petroleum refineries already use a million pounds annually in refining gasoline. A major use for molybdenum sulfide will undoubtedly be as a lubricant. One trucking firm in a test of chassis grease fortified with moly sulfides was able to increase mileage between grease jobs from 1500 to 6000 miles. Rolls-Royce has tried sealing chassis bearing points with grease fortified with the sulfide. All of these applications will have to compete with farmers and paint manufacturers for moly. If soil lacks moly, crops won't grow, and molybdate orange is growing in use because of its superior light fastness, tinting strength, and "hiding" power" compared to chrome oranges. Climax isn't too upset by this situation; moly is one of the few metals the United States can afford to export without fear of running out at home.

To familiarize Dr. Dean with moly compounds, Climax has assigned him as a first task the editing of a long brochure on the properties of moly chemicals. When the brochure is published in a few months, it will be the most up-to-date source of moly compound data. The present standard is a German book published 20 years ago. Dr. Dean will have to sandwich this unusual assignment for a consultant between his other duties as technical director of the U. S. Government's huge nickel mining and refining operation at Nicaro, Cuba, and as consultant to other firms. About 15 to 20% of Dr. Dean's time goes to Climax and most of the rest to the Nicaro project.

High Temperature Coatings

Climax is engaged in some research and development in molybdenum itself. At its Detroit laboratories metallurgists are attempting to develop high-temperature coatings for the metal. Uncoated moly oxidizes at high temperatures, and the oxide, unlike that of aluminum, is volatile. Coatings have been produced that enable the metal to withstand temperatures of 1800°F. Their goal is over 2000°F. If this project is successful, there are possible applications in jet engines and other devices that operate at high temperatures. Moly is very tough at these high temperatures.

Climax is gathering together as much technical data on moly compounds as possible. It will make this information

available to industry as it is obtained. Battelle Memorial Institute in Columbus has been given a contract to make literature searches in the moly chemicals to advance this project. Battelle has also been given a one-year contract towards broadening the use of phospho- and silicomolybdates in organic pigments and evaluating new applications for the normal molybdates, the cyanomolybdates and molybdenum disulfide. It will also survey potential markets resulting from investigations of these chemicals.

Soviet Professional Manpower

In recent years, the hue and cry in this country on the varying emphases placed by the Soviets and Americans on training of scientists has reached almost deafening proportions—and with considerable justification. For the major difference between Russian education and that in the U. S., according to the volume *"Soviet Professional Manpower"*, lies in the heavy emphasis on the type of Soviet training represented in America by technical institutes.

In Russia, there are some 1,500 "technicums" which give a type of technological instruction generally above the high school level, but not aiming for professional competence in the sense of our engineering schools. The rate of graduation from these technicums has been substantial—about 60,000 per year in the field of engineering alone.

Russian educational institutions also place heavy emphasis on basic science instruction in the lower grades. Even in the elementary grades 1-4, inclusive, 28% of the subjects are in the mathematics and science categories. In the intermediate grades over one-third of the time is spent on such subjects; in the upper grades over 40% of the time.

The same emphasis is apparent in Russian institutions of higher learning. In the engineering and industrial fields alone there are about 177 institutes for technological training associated with the technicums. This does not include the scientific training given in the 33 Soviet universities.

Soviet engineering training is characterized particularly by the long hours, the full weeks and the substantial period of the year spent in actual attendance at class, all greater than in corresponding situations in this country. There is also a heavier concentration on studies related directly to the individual specialization. Thus in an engineering curriculum only 6 to 8% of the time is spent on political and socio-economic courses. Over a quarter of the time is spent on the general sciences and another quarter on general non-specializing engineering. Narrow specialized engineering takes the rest of the time, with the exception of 6 to 10% of the curriculum devoted to physical and military training.

It is interesting to note that the Russians pay consistent attention to the student-teacher ratio in their schools. In 1940 there were 28 students per teacher, but by 1950 this ratio had been reduced to 23 to 1. It seems probable that the ratio will be further reduced, the exact reverse of the situation in America today, where the teacher shortage is one of our gravest dilemmas.

Soviet Professional Manpower was undertaken by the Office of Scientific Personnel of the National Academy of Sciences-National Research Council in the spring of 1952. Preliminary research was carried out by Boris Gorokhoff of the Library of Congress; final research and writing was done by Nicholas DeWitt of the Russian Research Center at Harvard University. The volume was financed by the National Science Foundation through the Government Printing Office.

Serendipics

EUREKA! Tomorrow's Bed Won't Have to be Made

After 3000 years the designers have finally gotten around to a problem that's irked the little woman since history's dawn—the daily bedmaking chore. Tomorrow's bed, says Jay Doblin, director of Illinois Tech's Institute of Design, will fold away automatically and be sterile cleaned when not in use. And that's not all. This snooze apparatus won't need such old fashioned contrivances as blankets; a radio-frequency unit will encircle the slumberer and keep him comfortably warm no matter what the outside temperature—unless the power fails.

But here's the payoff: The bed's softness or firmness could be regulated hydraulically or pneumatically. Doblin concludes that since people spend roughly one-third of their lives in bed, it's high time it was improved. This seems to us to be an unassailable premise, and we wish the bed designers well. Ditto the beleaguered little woman.

Researching Junior's Toys

No area of the economy, it seems, is immune to the penetrating (if occasionally absent-minded) gaze of the professional researcher. Take the toys the scion of the family gets, for instance.

Dad may very well bring home an 18-inch robot which does all of the following: walks, talks, swings its arms, picks up objects, and lights its eyes. We have not been able to learn whether this wonderful creature can help Junior with his sums, thus relieving said Dad of an onerous chore, but presumably that is the next logical step.

Or, for another example, consider the toys for the younger set (age 2-6) on which have been lavished years of research to make them stainproof, breakproof, corrosion proof, heat proof, scratch proof and just about every other kind of proof except 100 proof. But the toy researchers have gone a step further. These things are educational too. A recent numbers toy we examined, for juveniles in the 4-6 category, was so complex in its mathematical ramifications that even the great Univac would blink twice before tackling it.

Abechamycin — Name Without a Drug

Ever hear of Abechamycin? It's not a new antibiotic, although some day it might be. Right now it's just a name without a drug, the first of 42,000 in a new dictionary compiled by an electronic word wizard.

Authored and printed automatically by a huge electronic "brain", the 198-page lexicon is used by Chas. Pfizer & Co., Inc., Brooklyn, as a source book for naming new drugs.

Rules were devised to guide the IBM 702 in its screening operations. The new words must be easy to pronounce, spell and remember, easy to trans-literate into foreign languages, and should have a "medical sound".

Instructions on high speed magnetic tape were fed into the machine and the "brain" spewed out page after page of such potential drug names as Byulamycin, Platuphyl, Cliohacyn and Starycide. It completed the job in less than two hours with a final jawbreaker, Ywuvite.

The machine's super-human drug vocabulary includes not only usable trade names, but some words that can't be used for publication. It still takes a human to sort those out.

Developments

Cost Reduction, Lab Advances and the Standard of Living

During 1956 the nation's laboratories will develop new techniques and devices to save industry more than a billion dollars, according to Ernest E. Johnson, general manager of GE's General Engineering Laboratory. New advances, some fresh from laboratories and others still on the test benches, will improve the efficiency and reduce the cost and time factors of existing methods and processes. The savings will be reflected in lower consumer costs, higher quality and better living standards, he said.

"The growing emphasis on research and development in American industry is bearing fruit steadily," Johnson stated. "Engineering horizons are expanding continuously, and I feel we've hardly scratched the surface."

Lawrence D. Miles, value analysis expert for GE, said in a talk before the Los Angeles Association of Purchasing Agents that human nature is one of the big barriers to cutting costs. He warned that high costs are the only sure method of reducing the standard of living and cautioned against making products that are out of the reach of the many.

Value analysis, Miles said, is the scientific and sensible evaluation of whatever costs money. It covers parts, assemblies, services, processes and ideas, but under no circumstances does it ever involve any quality deterioration. Whether it be a single item or quantities in the millions, purchasers should know when they hand out their company's money that full value is coming back. At GE, Miles said, creative study of the function of parts continually contributes to lowered production costs.

Engineers Approve Co-op Course

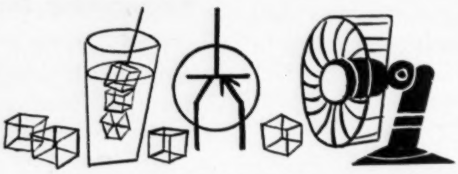
A majority of the engineers who worked while attending a cooperative engineering course during the past 10 years feel that it has been of benefit to them. The results of a survey of alumni of such a course at the University of Michigan were presented at the Winter General Meeting of the American Institute of Electrical Engineers this month by J. A. M. Lyon and C. E. Watson.

Of those graduates having more than three quarters of cooperative industrial experience, 94% felt the training was of value to them and 85% believed it was of sufficient value to justify the extra year in school. Of those holding the master's degree, about 75% believed it was of sufficient value to justify the extra year. Graduates with co-op training are more in favor of it than graduates without such training.

No Diminishing Returns in Research

"A doubling, tripling or even quadrupling of present over-all industrial research expenditures would seem possible before returns from research begin to diminish disproportionately," says Dr. Clyde Williams, president of Battelle Memorial Institute. Since the nation is spending only about one percent of each dollar on research, Dr. Williams believes that we have a long way to go before the law of diminishing returns takes hold. He predicts a national expenditure of 4½ billion dollars for research in 1956 if the nation's total production of goods and services reaches $400 billion.

"Cooling–Off" Improves Transistors



Transistors operating in the very high frequency band are being made at the Westinghouse Research Laboratories by a new "cooling–off" process. If new techniques such as this one for making transistors are developed in the next few years as rapidly as they have been lately, then the solid-state device should soon be able to compete with the vacuum tube over a very wide frequency range. And the cost of transistors should drop too.

Dr. R. L. Longini originated the improved method of making junction-type p–n–p germanium transistors. The technique is a modification of conventional methods rather than a radical departure like General Electric's "rate-grown" and "melt-back" processes and Philco's "surface barrier" approach. Commercially available surface-barrier transistors operate at frequencies up to about 50 megacycles and they have been operated at around 200 megacycles when made in the laboratory.

Inherently, the p–n–p transistor does not have the theoretical upper frequency limit of the p-n-i-p transistor. Developed at Bell Telephone Laboratories, these "intrinsic barrier" transistors have a theoretical upper limit of 10,000 megacycles. A number of development groups throughout the industry are experimenting with them at frequencies as high as 900 megacycles.

New semiconductor materials such as silicon and the intermetallics are another major avenue of development in transistors. Although a number of manufacturers are known to be making silicon transistors on a pilot-plant basis very few are available commercially. Another line of development is in new transistor configurations such as the "field-effect" transistor made by Sylvania on a pilot plant basis.

No Delicate Temperature Control

Conventional methods of making transistors rely on delicate temperature control to achieve quality and consistency in the finished product. A thin slice of n-type germanium is placed between two layers of the metal and heated. Atoms of the metal "dissolve" inward through the germanium, forming two outside layers of p–type germanium and leaving a very thin n–type layer between them. The thinner and more uniform the n-layer, the better the performance of the finished transistor.

If the processing temperature is too high, the very thin n–layer melts away completely, leaving the transistor worthless. Too low a temperature leaves the n-layer too thick resulting in poor transistor performance. In contrast, the new Westinghouse modification allows the temperature to be virtually uncontrolled; thus the technique inherently produces transistors more consistent in quality from unit to unit than those made by the older methods.

Key to the Westinghouse process is a "cooling–off" period during the heating of the transistor. The method allows the critical n–layer to build up to the desired thickness and uniformity instead of being inexactly dissolved away. The technique has also been applied to producing very sensitive phototransistors.

Nitroparaffins Research

At the recent Nitroparaffin Symposium in Chicago sponsored by Commercial Solvents Corporation, 150 representatives of mid-west industries met to hear a panel of research scientists and product development executives present their findings on nitroparaffin research and uses. Among the results reported were new plastic-like materials, long-lasting high gloss waxes, non-skinning paints, color-fast cosmetics and improved electro-coatings.

The nitroparaffins are a joint development of Commercial Solvents Corp. and Purdue University, where the possibility of commercial usefulness first became apparent in 1934-35 through the work of Dr. Henry Hass and his associates at the Purdue Research Foundation. The long term development program has led to the training of 50 students as Ph.D's in chemistry and seven others as Masters of Science in the same field, according to Dr. Ralph A. Morgen, Director of Research for the Foundation. It has also resulted in a patent portfolio of more than 40 patents protecting the original process improvements and derivatives.

According to W. Ward Jackson, Commercial Solvents vice president, nitroparaffins research is being intensified. As new derivatives are evaluated, a steady flow of developments of interest to industry and agriculture is expected.

Computer Favors Magnetics Over Transistors

Getting the jump commercially on all-transistor computers, a giant computer largely made up of magnetic amplifiers will soon be delivered to the armed forces. Many design details of the tiny high-frequency magnetic amplifiers used in the digital machine were revealed by Sperry-Rand engineers at the recent Winter General Meeting of the AIEE in New York. Its designers claim the computer has the reliability of its silicon diodes, a very reliable device. Some experimental all-transistor computers have already been built, but none have been delivered for use to date. Magnetic amplifiers are much less affected by temperature changes and high temperatures than transistors. It will be interesting to see if magnetic or transistor computers take over the giant-computer field in the coming years.

High-frequency magnetic amplifiers such as the "Increductor", "Magnistor" and "Ferristor" have been available for up to two years in the case of the first named, but they operate at power levels too high for use by the hundreds or thousands in giant computers. They are better used in machine controls where higher power levels are necessary. The magnetic amplifiers in the new Sperry-Rand Univac computer operate at very low power levels because of their size and construction. High-permeability material is used in the cores instead of low-permeability ferrites. Another advance is the use of stainless steel instead of ceramics for the coil bobbin. Stainless steel bobbins permit lower power levels and are "three times better than ceramic" according to Theodore H. Bonn of Sperry-Rand. The coil wire is only two mils thick.

Mo-Permalloy tape only ⅛ mil thick is the core material. After being wrapped through the bobbin, the last layer of tape is spot-welded to the layer below. The outside diameter of the complete core is only 0.150". Along with associated components, the magnetic amplifiers are mounted in pairs in headers, then potted in soft Silastic. Although many details of the amplifiers were revealed, it is unlikely that other designers will be able to duplicate them in the near future. The secrets are in making the amplifiers. They will not be available as separate components.

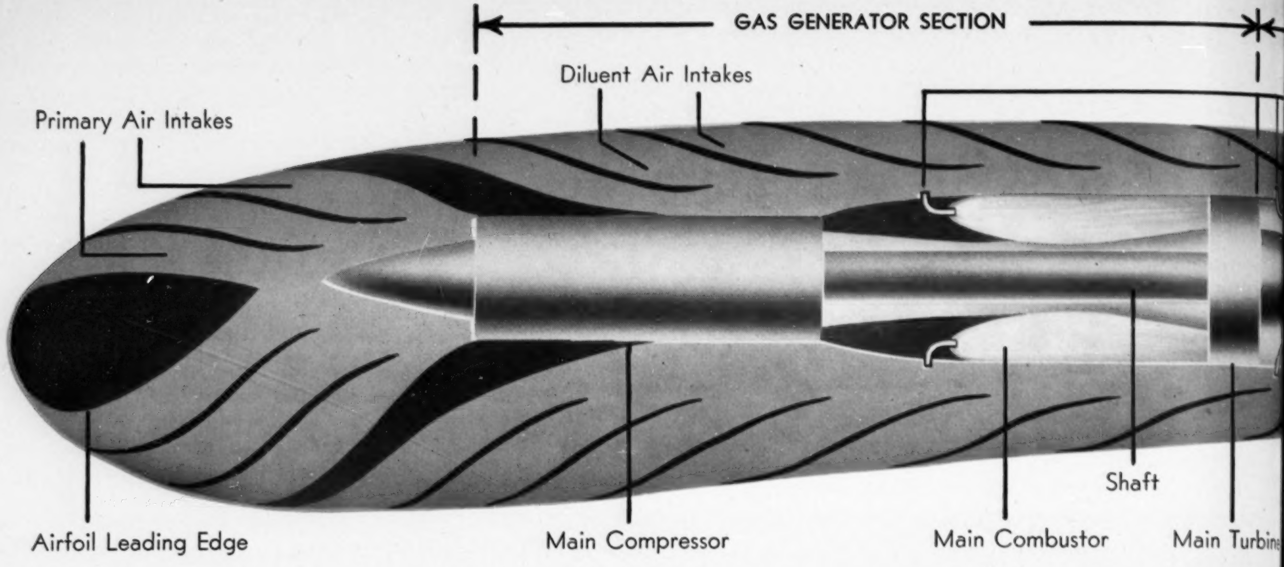
Some tubes and transistors are also used in the computer, but the designers are working to eliminate the tubes. They emphasized that each amplifying component was used where best applied; they did not sacrifice performance just to eliminate tubes or transistors in favor of magnetic amplifiers. For example, transistors are used in the input section where their low-level amplification characteristics are better than those of magnetics. The entire computer was designed as a system, and not by replacing vacuum-tube circuits one-by-one by equivalent magnetic-amplifier circuits.

Much interest was shown in the work by the audience, and the significance of the advances was emphasized when Robert A. Ramey, manager of magnetic engineering for Westinghouse, stood up and congratulated the designers on their accomplishments. Ramey is well known for his work in this field. Sperry-Rand intends to apply the techniques of this computer to commercial machines after fulfilling the military's needs.

Oxygen Needed for Enamel Bond

Oxygen plays a vital role in the adherence of enamels to metals. The same study of the adhering mechanism by the National Bureau of Standards showed that adherence increased with increasing roughness of interface between enamel and iron. Since coated metals are particularly important in jet turbine construction, the National Advisory Committee for Aeronautics requested the NBS study.

A series of experiments was conducted in which the oxygen content of the firing furnace atmosphere was varied when the same enamel containing varying amounts of an adherence promoter, cobalt oxide, was fired onto iron. For best adherence any decrease of oxygen in the furnace required a corresponding increase in the cobalt oxide in the enamel. The conclusion is that the cobalt oxide is in some way supplying or facilitating the supply of some of the oxygen, since the amount of cobalt oxide is the only difference.



A COMPOUND-REHEAT DUCTED-FAN ENGINE SYSTEM ARRANGED

ISRAEL KATZ

POWER-The Key to Fligh

Although the airplane and its flight operations have been brought to states of development where further major improvements are with few exceptions almost prohibitively expensive and difficult to conceive, the feeling that the airplane will soon be a radically different vehicle cannot be dispelled. Commercial aviation has matured so rapidly that it now has many of the traditions and trappings of the railroad. Even greater progress has been made in military aircraft; the combat airplane has been perfected so highly that it manifests some of the agility and reflex action found in nature. Hardly a serious operational problem confronts either commercial or military aviation that resists solution by existing techniques and know-how. Yet much of this achievement may be swept aside by startling advances that will be at hand when the thermal barrier yields to the scientific inquiry and engineering skills being brought to bear upon it.

The question "If this is so, then where do we go from here?" logically arises, but it is a question to which there cannot be a pat answer. A valid answer must be qualified by factors that affect trends in aeronautics. It is not so much the purpose here to predict the shape of things to come as it is to examine those factors that influence advanced developments in very high speed flight with a view toward disclosing pertinent areas of research and engineering that merit immediate stimulation.

Circumspection

Before this examination can be undertaken, however, consider the frame of mind essential for a forthright approach to the task. Not so long ago the very thought of jet propulsion seemed ludicrous; its proponents were hardly taken seriously. Today, a statement that hints, even slightly, at the possibilities of a carefully considered practical limitation to the success of some farfetched scheme is apt to mark the skeptic as inhibited and unimaginative. That the pendulum of credulity swings widely for the technological conformist is understandable. The gifted technical person grasps noteworthy ideas at once. He is intrigued by them; and, given the proper environment, will move to implement them within the scope of his capabilities, consistent with his understanding of what constitutes sound engineering.

It is, therefore, necessary to bear in mind, when considering trends in aeronautics, that the expenditure of enormous effort and funds devoted to radical advances must be justified in terms of practical benefits the associated developments will bring. Every major facet of these developments will have to withstand enlightened but critical scrutiny from viewpoints of realistic utility, performance, endurance, safety, versatility and economy.

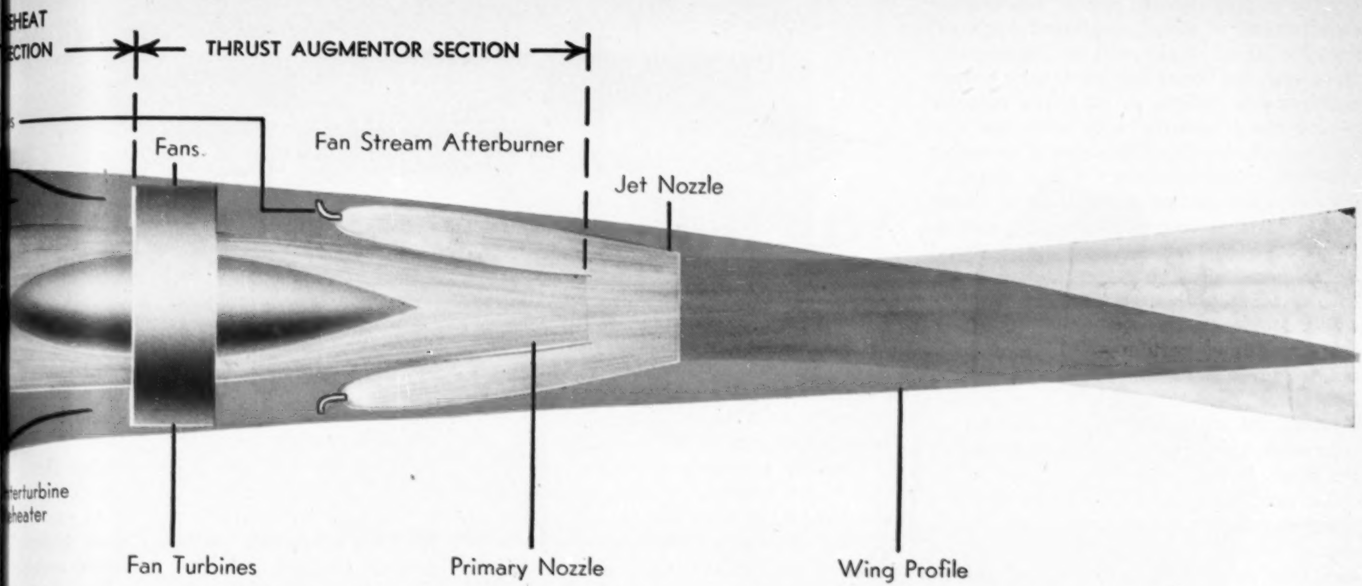
Challenge

Man's recent conquest of the sonic barrier marked an important point of departure in aeronautical progress. We not only are well aware of the tremendous strides taken in subsonic flight, but also impressed with the public's acceptance of commercial aviation as a major form of transportation. While much is still to be accomplished in practically every aspect of flight, the subsonic airplane is a mature and substantial device.

Important technological advances also have been made in supersonic flight. Perhaps the most significant accomplishment has been the realization that attainment of sustained flight at high supersonic speeds requires an extraordinary assault upon problems of enigmatic complexity and sobering proportions. Willingness of the aviation industry to face the challenging task is one of its most inspiring aspects. Perplexing problems confronting the development of fully acceptable steep-gradient aircraft, and the seemingly insurmountable obstacles to sustained high supersonic flight are bound to give ground before the vast forces of technology now mobilizing for the attack on the thermal barrier: crushing drag and withering heat impediments to very fast motion through the atmosphere.

The Key

Propulsive power and its effective utiliza-



CT BOUNDARY-LAYER AIR FROM AIRCRAFT WING SURFACES

eyond the Thermal Barrier

tion are the mainsprings of past and future progress in aeronautics. Unless this fact is understood in its full import it is impossible to comprehend, to properly appraise, to intelligently plan further development. Recent months have illustrated the dire consequences of failure to realize the significance of propulsive power.

Some people may wonder why the principal production output of a highly developed combat airplane and its inadequate powerplant had to be discarded at a loss exceeding two-hundred million dollars. Those who wonder why another but larger engine cannot be fitted properly to that airplane or why the inadequate engine cannot be used efficiently in a smaller airframe do not understand how critically a powerful engine relates to a high speed airframe and to their combined operational behaviour.

More than ever before the powerplant will play the dominant role in aircraft design. In the main the engine will dictate the configuration of the vehicle and determine its flight capabilities. Not only will the powerplant be required to lift, propel and cool the airplane, but also it will be difficult to distinguish between the engine and airframe structures. The accent, then, is on power and upon those factors that favor or enhance its effective utilization.

The New Scheme

In the long run, speed is the prime commodity of aviation and power is required to obtain it. However, as speeds rise the wings shrink. It then becomes increasingly difficult to develop sufficient lift at low airspeeds without introducing prohibitive drag forces. A means for avoiding high drag forces at the lower airspeed, where the angle of attack otherwise must be high to produce the necessary lift, resides in the enlistment of propulsive thrust to provide the principal lift until whatever aerodynamic lifting surfaces remain can take over.

Apart from challenging operational problems associated with the inevitable steep-gradient aspects of high-supersonic speed aircraft, and the complexities related to the intense aerodynamic heating of aircraft skin at high speeds, will be the seemingly overwhelming difficulties of producing sufficient propulsive power and of applying that power with favorable propulsive efficiencies. At this moment there is little doubt that high supersonic speeds can be achieved with a variety of powerplants, but careful thought relating to the capabilities of applicable engine-airframe combinations leads to the conclusion that sustained and economical supersonic flight can be achieved only by the use of highly integrated turbojet engine-aircraft combinations, providing that their modes of operation at design speed, in a broad sense, closely approach those of the ram jet engine or the rocket. Since turbojet and ram jet engines effect propulsion by the acceleration of ambient air that is inducted continuously from the environment, whereas rocket propulsion results from the acceleration and rejection of propellant carried along by the rocket, a brief explanation seems appropriate.

In the case of conventional turbojets, atmospheric air approaches the engine with a relative velocity equal to the airspeed (V_a) of the flight vehicle. After being processed by the engine, the same air, with minor changes in mass and composition due to the addition of fuel and occurrence of combustion in the flow, is rejected at an increased jet velocity (V_j). Maximum propulsive work and, possibly, the optimum propulsive efficiency occur when $V_a = V_j/2$.

This equation illustrates an important practical limitation of conventional turbojet engines in propelling high speed aircraft. For any desired specific thrust, the corresponding required change in specific kinetic energy of the flow rises rapidly with the increase of vehicle airspeed. That is, if

$$V_{a2} > V_{a1} > O$$

and if

$$V_{j2} - V_{a2} = V_{j1} - V_{a1} = V_{j0} - O,$$

then

$$(V_{j2}^2 - V_{a2}^2)/2g \gg (V_{j1}^2 - V_{a1}^2)/2g > (V_{j0}^2 - 0)/2g$$

Therefore, unless some means for mitigat-

ing the related thermal energy expenditure requirement is found, sustained high supersonic speed flight will be impractical. Of course, the larger specific kinetic energy requirements reflect, in part, the increase of specific propulsive work with the rise of airspeed; but the difficulties of releasing sufficient chemical energy within the confines of a combustion gas turbine to obtain the essential power level are, in practice, aggravated further by the rapid rise of aerodynamic drag and propulsive power requirements with the increase of flight speed. Moreover, the serious loss in physical strength of turbine parts at elevated temperatures and the necessary increase of total mass flow through the engine with airspeed set early limits to the overall acceleration that can safely be effected in the flow.

An intriguing solution to this seeming dilemma may lie in the continuous induction of boundary layer air and its acceleration to a relative velocity slightly greater than that of the surrounding free stream. Since the boundary layer air is substantially at rest relative to the airframe, if that air were swallowed, heated, and accelerated to the free stream velocity by some form of turbopowerplant-airframe combination designed to induct boundary layer air, the resulting action could, in theory at least, permit complete utilization of the kinetic energy imparted to the air for propulsion and may accomplish this remarkable feat without incidence of excessive flow velocities in the engine.

Such an engine-airframe combination in effect constitutes a ram-jet engine, but, since the engine would accelerate the working medium from rest, it should not be necessary to develop exceptionally high jet exit velocities to obtain a high gross propulsive thrust. In that sense the engine-airframe combination acquires the properties of a rocket. It, therefore, should be evident that the principal advantage of utilizing boundary layer air as the propulsive medium stems from crediting the engine, in large measure, with the drag loss incurred by the airframe and from an ability to produce high specific thrusts without need to develop exceptionally high flow velocities in the engine's jet nozzle.

The Powerplant

Several methods for producing sustained propulsive thrust at high supersonic speeds will evolve eventually. But, considering numerous critical requirements that must be met and practical limitations attending efficient conversion of tremendous quantities of heat into effective propulsive work, all present contemplations of suitable propulsion systems inexorably lead to the conclusion that a compound-reheat ducted fan engine is the logical powerplant; providing, of course, that it too can appropriately be integrated with the airframe to benefit adequately from boundary layer air induction and repeated reheat necessary to the high energy release rate.

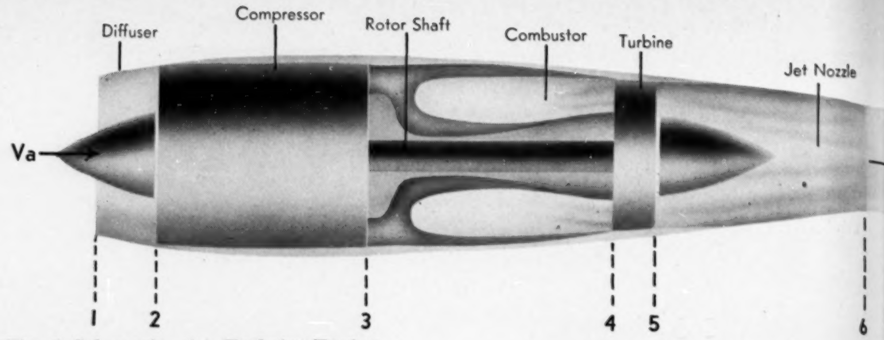


Fig. 1 Schematic of a Turbojet Engine

The ducted fan engine, essentially a modified form of a turbojet, was conceived originally as a means for increasing the thrust developed by aircraft gas turbines at subsonic airspeeds without the encumbrances of a propeller and without compromising propulsive efficiency or degrading thermal efficiency. Thrust boost was to be achieved by accelerating a greater weight of air than is processed normally through conventional turbojet engines of comparable thrust power, but to discharge the greater weight of flow at a lower jet exit speed. Equations for specific thrust and propulsive efficiency of turbojet engines show that propulsive efficiency increases as V_j is reduced toward V_a, but also that the specific thrust is decreased upon doing so. Thus, it does not follow that an increase in the mass flow of air, which is ultimately discharged at a lower jet speed, necessarily results in a thrust boost. The trick is to increase mass flow faster than the jet exit speed is reduced. To handle a greater weight of air, without seriously reducing the engine's cycle efficiency or raising the combustion temperature above limits imposed by the turbine blades, it is necessary to process, with great care, only part of the total air through the combustors.

The general pattern that has evolved embraces the merging of separately compressed diluent air with pressurized hot gases from the engine's turbines and the subsequent expansion of the mixed flow through a jet nozzle to produce propulsive thrust. This scheme does permit maintenance of the highest allowable combustion temperature in the primary flow and consequent attainment of favorable fuel economies.

However, designs of existing ducted fan engines are hardly consistent with the requirements for high supersonic speed aircraft propulsion because of the prohibitive drag losses that their design would engender and their inabilities to develop adequate specific propulsive power.

Fig. 1 illustrates the typical composition of conventional turbojet engines. The diffuser provides ram compression by decelerating the incoming air. Then, the compressor raises the pressure level of the air, above the relatively low ram-pressure level, not only to permit the addition of heat to the air in great quantity and with proper rapidity within the confines of the engine to make practical and efficient engine operation possible, but also to provide sufficient pressure drop across the jet nozzle to develop significant propulsive forces.

The turbine drives the compressor. However, since a pressure drop in the flow also is required across the jet nozzle to convert the flow's sensible enthalpy into kinetic energy, the drop of total pressure across the turbine should be less than the rise in total pressure across the compressor, but it must be less than the total pressure rise across the diffuser and compressor. This pressure drop requirement is brought out in Fig. 2. Neglecting the effects of pressure losses in the mechanical operation of an engine, viscous friction in the flow and minor differences in the weight rates of flow through the compressor and turbine (due to the addition of fuel to the air in the combustors), the change of enthalpy across the turbine must equal the change of enthalpy across the compressor. Thus the overall change in specific kinetic energy of the flow effected by the engine must be equal to the corresponding net difference between the sums of specific enthalpy changes occurring in the flow beyond the combustors on the one hand, and ahead of the combustors on the other. The relationship that applies here may be written as

$$(V_j^2 - V_a^2)/2g = (H_5 - H_6) - (H_2 - H_1)$$

when

$$H_4 - H_3 = H_3 - H_2$$

Some important effects due to deviations from the ideal that have considerable bearing upon the application of compound-reheat ducted fan engines also are brought out in Fig. 2. The pressure change across an ideal diffuser would have been

$$\Delta P_{1-2'} > \Delta P_{1-2}$$

for the same conversion of kinetic energy into potential energy:

$$\Delta KE_{1-2} = \Delta K_{1-2'} = (H_2 - H_1) = (H_{2'} - H_1)$$

Similarly, with an ideal jet nozzle, the energy converted would have been

$$H_5 - H_{6'} > H_5 - H_{6'}$$

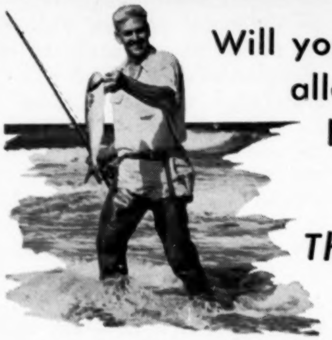
which is the actual energy converted in the nozzle. Furthermore, if

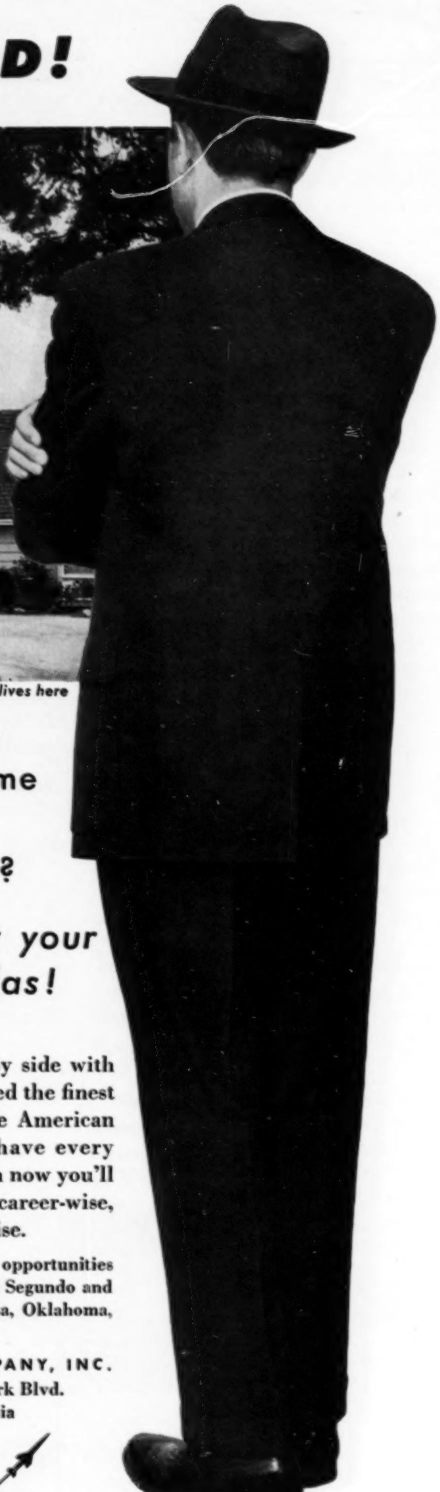
$$H_5 - H_a = H_2 - H_1$$

the net energy converted by the engine is

ENGINEERS...
LOOK TEN YEARS AHEAD!

A Douglas engineer lives here





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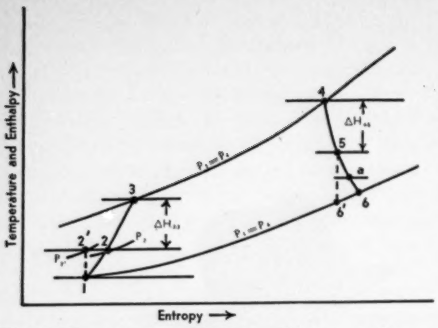


Fig. 2 Temperature-Entropy Diagram for a Conventional Turbojet Engine

only

$$H_a - H_6$$

Thus, since $H_4 - H_3$ represents the heat added to the flow, the cycle efficiency of the turbojet engine may be expressed as

$$\eta_c = (H_a - H_6)/(H_4 - H_3)$$

Fig. 3 illustrates one of the most promising forms of ducted fan engines intended for conventional aircraft propulsion. It consists of a turbojet engine which feeds hot pressurized air to a "thrust augmentor" containing a set of contra-rotating turbines that drive a group of fan blades fastened to the peripheries of the separate turbine wheels. Primary flow merges with the compressed diluent air at the discharge of a primary jet nozzle and the resulting gas mixture expands further through a main nozzle to produce propulsive thrust.

There are several ways in which thrust augmentation by flow dilution can be achieved, but, only where the thrust augmentor turbines "float" in the gases issuing from the main turbine and only where the ducted fans do not influence the pressure level in the combustors, will the dilution ratio adjust automatically, rapidly and correctly to any change in engine operating conditions.

Since maximum propulsive work and, possibly, the optimum propulsive efficiency of reaction propulsion devices occur when $V_a = V_j/2$, one of the guiding design objectives for economic operation of subsonic ducted fan engines is achievement of a jet discharge speed approximately equal to twice the flight speed. However, the key to realization of the remarkable performance capabilities of the subsonic ducted fan engine is operation with optimum dilution of primary discharge by secondary air; because only with optimum dilution will it be possible to obtain economical operation without compromising thrust or propulsive efficiency.

Determination of any required steady-state optimum dilution ratio is a matter of analysis and experimental tests. Principles related to the pertinent analysis, and the influential factors affecting the highest-economy dilution ratio, may be illustrated with reference to Figs. 3, 4, and 5 as follows. The energy converted across the main turbine must always equal the energy added by the main compressor to the flow passing through it. Similarly, the energy converted across the fan turbines must equal the corresponding energy change in the secondary flow passing through the fans. The dilution ratio, y/x is then selected in such manner that after the primary flow x and the diluent flow y are merged at station 8 and subsequently expanded through the jet nozzle, the gases leave the engine with a relative velocity equal to twice the airspeed of the flight vehicle. The optimum value of y/x for the subsonic non-reheat case may be expressed in terms of the principal independent design and operating variables as:

$$\frac{y}{x} = \frac{\eta_{en}\,\eta_b\,F\,HV_p\,[1-(1/\gamma)]}{4\beta - \eta_{en}\,(c_p\,T_o + \beta)\,[1-(1/\gamma)]} - 1$$

where

$\gamma = R_{en}^{(k-1)/k}$

$\beta = V_a^2/2g$

η_{en} = Jet nozzle expansion efficiency

η_b = Combustion efficiency

F = Fuel/air weight ratio

T_o = Ambient air static temperature

HV_p = Constant pressure heating value of the fuel

R_{en} = Jet nozzle expansion ratio

V_a = Airspeed of the flight vehicle

c_p = Specific heat of ambient air at constant pressure

g = Gravity constant

k = Ratio of ambient air's specific heats at constant pressure and volume

It is now possible to postulate, in general terms, the composition of a high supersonic speed ducted fan engine and show why it differs from its subsonic counterpart. Before doing so, however, the principles of the ram jet should be described briefly to demonstrate how the work of ram compression can be used to gain an important propulsion advantage; the performance of a high supersonic speed ducted fan engine will be critically dependent upon the engine's effective utilization of ram work energy.

In a ram jet engine air enters the diffuser with great speed due to the fast motion of the engine through the still air. The air then is heated, usually by combustion in the flow, and finally rejected after expansion through a jet nozzle to produce propulsive thrust. Fig. 6 illustrates the cycle, which consists of ram compression 1—2, heating at constant pressure 2—3, expansion 3—4 and rejection of unconverted energy to the environment 4—1. If the engine were perfect, that is if it did not encounter external viscous drag and the air passing through the engine were processed reversibly and adiabatically, no heat would have to be added to the flow and the cycle would reduce to the superimposed lines 1—2′ for ram compression, and 2′—1 for expansion. Moreover, the highest pressure in the cycle would be $P_{2'} > P_2$.

With irreversible, but adiabatic, processing of the air through the engine, the cycle is defined by the points 1-2-3-4. Here $H_3 - H_4 = H_2 - H_1$, and the heat

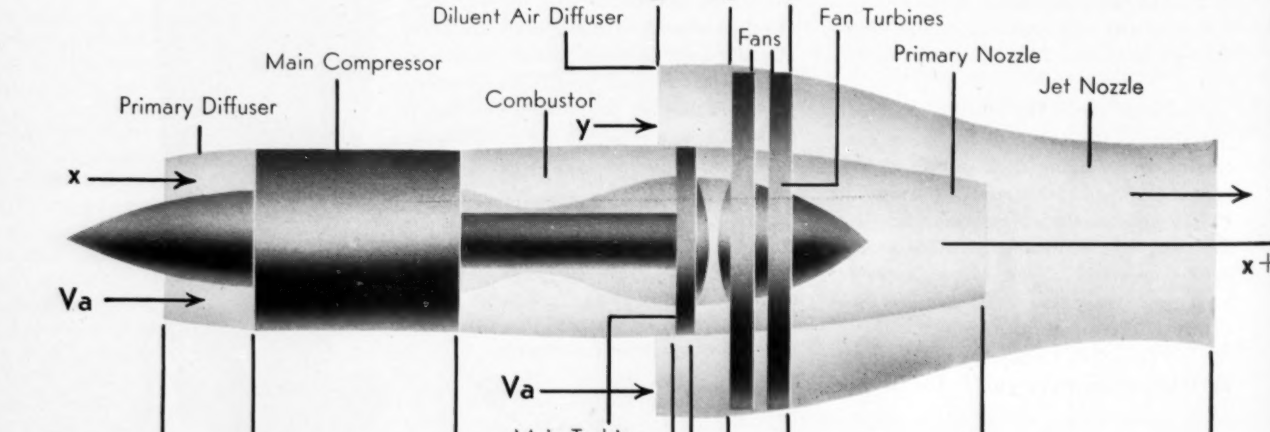


Fig. 3 Schematic of a High-Subsonic Ducted-Fan Engine

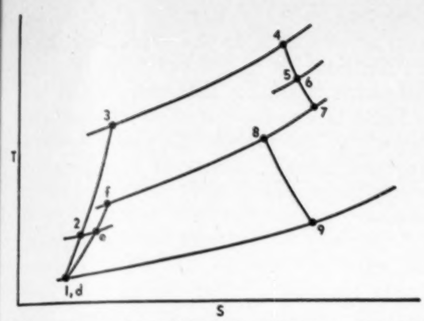


Fig. 4 Temperature-Entropy Diagram for the Ducted-Fan Engine Cycle

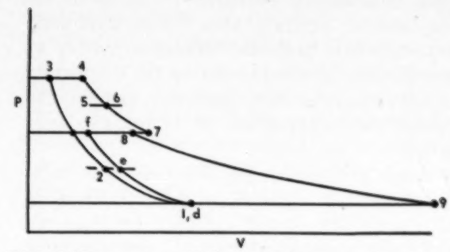


Fig. 5 Pressure - Volume Diagram for the Ducted-Fan Engine Cycle

added to the flow is $H_3 - H_2$. Furthermore, with external aerodynamic drag, due to viscous friction between the engine's skin and the still air the cycle becomes 1–2–5–6, where $H_5 - H_6 > H_2 - H_1$ and $(H_5 - H_6)$ minus $(H_2 - H_1)$ = the net specific propulsive work.

Design Objectives

Thus, the requirements that must be met in the design and operation of long-range high-supersonic airspeed engine-airframe combinations are:

- Develop sufficient sealevel thrust to permit vertical takeoff and landing at full load.
- Operate economically during most flight conditions, but particularly at high altitudes and airspeeds.
- Achieve substantial thrust boost by utilizing to advantage the major portion of ram air work resident in the aircraft's boundary layer.
- Produce very large amounts of propulsive work.
- Possess a structure that is light, but also rugged and flexible. Furthermore, the engine should be easy to install and service.
- Engine parts should not operate at undue speeds, temperatures and pressures.
- Provide sufficient compatibility of engine and airframe for extreme integration.

Projected Design

The schematic cross-section shown on pages 18 and 19 illustrates a simplified version of a compound-reheat ducted fan engine capable, in principle, of meeting all of the stated requirements. A thrust augmentor consisting of an integral compressor-turbine section, ducts and nozzles is shown located downstream of a secondary combustor that can provide interturbine reheat. An afterburner operating in the jet nozzle section of the thrust augmentor could produce additional thrust boost for take-off and very high speed bursts. While the overall length of the engine may exceed the length of conventional aircraft powerplants, separation of the thrust augmentor from the gas generator avoids the critical shaft deflection problems associated with other existing types of turbopowerplants and provides a measure of flexibility and versatility essential for wing installations.

Fig. 7 illustrates the cycle of a compound-reheat ducted fan engine integrated with the airframe to utilize entrained boundary layer air. The process 1—2 represents polytropic ram compression of the boundary layer air. Processes 2—3 and 2—3′ represent respectively polytropic mechanical compression of primary flow by the main compressor and secondary air by the fans. Primary flow is heated in the main combustors during the constant pressure process 3—4, expanded across the main turbine during the polytropic process 4—5 to drive the main compressor, reheated at constant pressure in the interturbine reheater during the process 5—6, expanded across the fan drive turbine during the polytropic process 6—7 and accelerated through the primary nozzle during the polytropic process 7—8. The energy relationships that apply here are:

$$x\,(H_4 - H_5) = x\,(H_3 - H_2)$$

and

$$x\,(H_6 - H_7) = y\,(H_{3'} - H_2)$$

Merging of the primary flow x and the diluent flow y occurs during the constant pressure process 8—8′, which is followed by polytropic expansion 8′—9 of the mixed flow through the main jet nozzle to produce the gross propulsive thrust. Thus, without after-burning,

$$(x+y)\,(H_{8'}-H_9) = (xH_7+yH_{3'})-(x+y)\,H_9$$

the net specific thermal energy converted is

$$Q_c = (H_{8'} - H_9) - (H_2 - H_1)$$

the ideal cycle efficiency of the engine is

$$\eta_c = \frac{(x+y)\,Q_c}{x\,[(H_4-H_3)+(H_6-H_5)]}$$

and the ideal thermal efficiency of the engine-airframe combination is

$$\eta_t = \eta_c[2V_a/(V_j + V_a)]$$

With afterburning in the combined flow during the constant pressure process 8′—8″, followed by polytropic expansion 8″—9′ through the jet nozzle.

$$(x+y)\,(H_{8''}-H_{9'}) = x\,(H_7+H_{3'}) + (x+y)\,(H_{8''}-H_8-H_{9'})$$

where

$$H_{8'} = (xH_7 + yH_{3'})/(x+y)$$

Then,

$$Q_c = (H_{8''} - H_{9'}) - (H_2 - H_1);$$

$$\eta_c = [(x+y)\,Q_c]/[xpq + (x+y)\,r]$$

where

$$p=H_4-H_3;q=H_6-H_5;r=H_{8''}-H_{8'}$$

and

$$\eta_t = \eta_c\left[\frac{2V_a}{(V_j+V_a)}\right]$$

In either case, if the sum of x plus y represents all of the airframe's boundary layer air, then

$$(H_{8'}—H_9) = (H_2—H_1)$$

without afterburning,

$$(H_{8''} - H_{9'}) = (H_2 - H_1)$$

with afterburning, and no net thrust is developed at constant airspeed.

On the other hand, if the sum of x plus y does not represent all of the airframe's boundary layer air, as will be the case in practice, then $(H_{8'} - H_9) > (H_2 - H_1)$ without afterburning and $(H_{8''} - H_{9'}) > (H_2 - H_1)$ with afterburning. In that event, even at constant airspeed, the net specific thrust will be

$$T_n = 2\left[(H_{8'} - H_9)^{\frac{1}{2}} - (H_2 - H_1)^{\frac{1}{2}}\right]$$

without afterburning, and

$$T_n = 2\left[(H_{8''} - H_9)^{\frac{1}{2}} - (H_2 - H_1)^{\frac{1}{2}}\right]$$

with afterburning.

It is inevitable that the lines and structural design of high supersonic speed engine-aircraft combinations will be set largely by objectives and functional considerations such as:

- performance compatibility of airframe and engine,
- reduction of aerodynamic drag,
- high resistance to skin heating,
- induction of boundary layer air,
- vertical takeoff and landing,
- resistance to high loads and wracking forces,
- long range capabilities,
- substantial payload carrying ability,
- maneuverability,
- dynamic stability,
- and airborne or surface based automatic control.

No doubt structural, propulsive and operational requirements related to the high supersonic speed flight of long range aircraft can be met and the effort and funds necessary to do so will be devoted for that purpose. It may be premature to plan a formal program of development, but there are several areas of investigation that merit immediate attention. Some of these pressing items, upon whose yield hinge many advances essential to the achievement of very fast flight, are discussed below.

Needed Research

First and foremost is the need to gather available pertinent information and to place that information at the disposal of workers in the field. Although many segments of the aviation industry possess a

wealth of applicable data and experience, the vast background is not shared by most of the young people who staff the industry's scientific and engineering organizations.

Boundary Layer Air

Probably the area of pertinent research that requires most attention is concerned with thermodynamic phenomena in the boundary layer air at very high speeds and high altitudes and effects thereof on airframe drag and powerplant performance. A fair amount of experimental data relating to boundary layer characteristics at subsonic and supersonic speeds have been accumulated and some information pertaining to airflow past very fast objects is being collected. Surprisingly, while there is some variance in details of theory and considerable disagreement in the parts that seemingly important factors and effects related to high speed flow play in contributing to aerodynamic drag, there is unusual agreement in calculated values of boundary layer temperatures and viscous frictional forces.

There is general agreement that at both subsonic and supersonic speeds aircraft skin heating is associated with effects relating to viscous shear in and near the boundary layer. There also is substantial evidence that at high supersonic and hypersonic speeds (faster than Mach 3), viscous shear phenomena give way to Newtonian flow effects where skin heating, for example, is due increasingly to impingement upon and penetration of the aircraft skin by air molecules. It is felt in some quarters that a transition from viscous shear effects to molecular impingement, followed by penetration, starts in the transonic range. The transition seems to be gradual and strictly a function of the relative speed and thermal properties of air, but a clearcut expostulation of the circumstances and effects relating to the transition, in sufficient detail to permit reliable prediction of boundary layer properties, flow phenomena, and drag at high supersonic speeds, does not to our knowledge exist.

Aerodynamic Heating

Another equally important and related area of essential research pertains to resistance of aircraft skin to aerodynamic heating. This problem, largely a matter of metallurgy, is found also to be intricately associated with flow patterns around the vehicle and properties of boundary layer air.

Analytical determination of skin temperatures for vehicles with configurations of very high speed aircraft involves an ability to determine the local conditions of flow over the various surfaces. Since local flow patterns vary considerably with flight conditions and the angle of attack of the aircraft, it will be extremely difficult to predict, with even modest accuracy, the local temperatures of boundary layer air and the effective local Mach number during very fast flight. Furthermore since the convective heat transfer coefficient is a function of local boundary layer properties and the skin's instantaneous temperature, which in itself is a function of previous heating or cooling, it also will be difficult to forecast local heat fluxes.

The technical literature contains valuable information on the aerodynamic heating of aircraft skins, but little bears directly upon the determination of skin temperatures at very high speeds other than where the vehicle's configuration can be approximated by a series of simple shapes such as cones and cylinders. Various methods, each involving successive approximation, are available for evaluating skin temperatures of such shapes and lead to results that have been partially substantiated by experiment. However, because each of these methods involve rather dubious concepts concerning phenomena in the boundary layer, it is doubtful whether they can yield meaningful values when applied to very high speed winged-aircraft.

A great deal of work already has been done with regard to the design of skins, cooling systems, and choice of skin materials for supersonic aircraft, but little of the knowledge gained is applicable to aircraft that will be capable of sustained flight at airspeeds on the order of Mach 3 and altitudes up to 100,000 feet. It seems reasonable to assume that every effort will be made to operate the skins of very fast aircraft at the highest allowable temperature and thereby reduce or eliminate the prohibitively heavy and bulky equipment necessary to cool the skin. While doing so will increase the internal cooling problem, the gain in payload and fuel economy should completely offset the internal heat-handling disadvantage. It follows, then, that in the presence of intense external heating, the allowable skin temperature will be set by the hot strength of the skin.

Metallurgy

Considerable effort is being directed to the further improvement of existing high temperature resistant alloys for possible use as materials for skins and airframe structures operating within the 600 to 1100 F temperature range. Among these metals are the well known martensitic, austenitic, and precipitation hardening steels in addition to the titanium alloys. Martensitic steels can be heat-treated to develop high strengths, but at high temperatures that strength is fleeting and the metal's corrosion resistance is poor. Austenitic steels generally have low hot strengths and do not respond to heat-treatment, but they are stable during prolonged heating and very corrosion resistant. The titanium alloys are lighter than the steels and possess very favorable strength-weight ratios as compared with other hot-strength alloys.

The applications of metals that can withstand temperatures ranging between 1200 and 2400 F are still limited by considerations of undue thermal expansion, poor heat conductivity, high surface emissivity, low scaling resistance and inadequate strength-weight ratio. On the whole, the alloys that retain sufficient strength to be used at temperatures above 1200 F are those containing either iron, nickel, or cobalt as the major constituent. In general, the alloys of iron are suitable for use at temperatures below 1500 F. Heat-treated

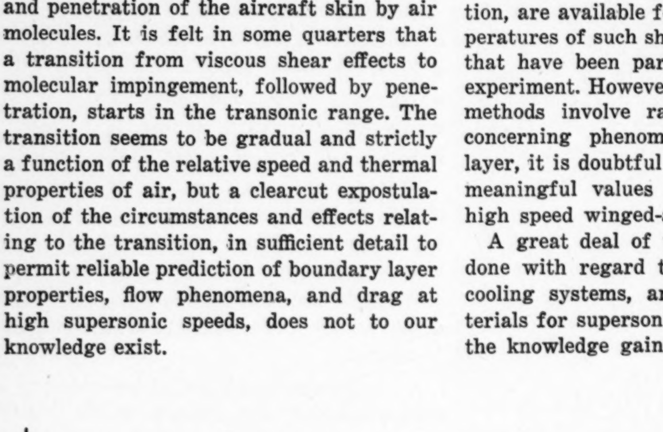


Fig. 6 Temperature-Entropy Diagram for a Ram Jet Engine

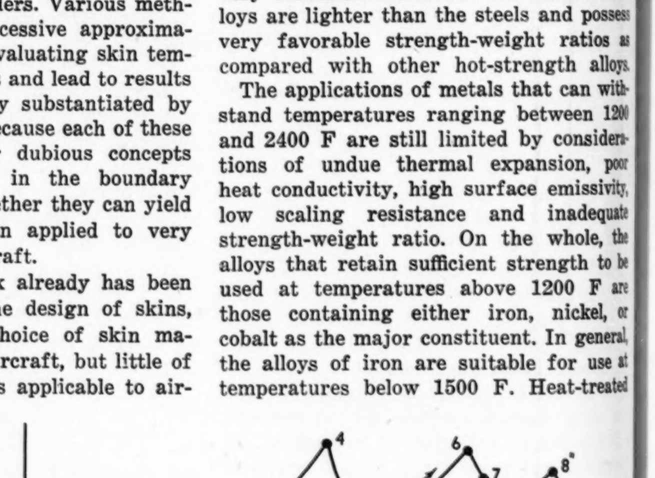


Fig. 7 Temperature-Specific Entropy Diagram for Combustion-Type Compound-Reheat Ducted-Fan Engine Without and With Afterburning for Added Thrust Boost

Inconel X is the strongest material up to about 1600 F, but it suffers severe loss in ductility at about 1200 F due to temporary hot-shortness. High-critical-material containing alloys, such as L-605 and S-816, retain the greatest strength at temperature above 1600 F, but are in very short supply. The strength levels of all existing alloys are very low above 1800 F, although high temperature parts of afterburners and ramjet engines can be designed to function up to 2200 F for brief periods.

It is premature to indicate what the effects of ceramic and cermet coatings will have upon the properties of high temperature resistant metallic skins. But experiences with ceramic coated engine parts that have been exposed to temperatures up to 1700 F for intervals of about 5000 hours demonstrate the possibilities for maintaining the durability of high alloy steel skins coated with ceramic materials for relatively long, although indefinite, periods of time.

Intimately related to the difficulties of maintaining adequate strength of the skin in the presence of intense aerodynamic heating, will be the entangled problem of properly decelerating and swallowing boundary layer air for processing through the engine. Here the ingenious design of suppressed air-intakes with the cautious injection of liquid fuel (perhaps through perforated walls of the airframe) in sufficient quantity to afford a measure of internal cooling in the walls and of the inducted air (but well short of the lean limits of flammability to preclude burning ahead of the combustion sections of the engine) should significantly reduce the specific work of mechanical compression and enhance the thermal efficiency of the engine-airframe combination. Thus the extraordinary effort now being devoted by certain government establishments and private industrial organizations to the effective induction and cooling of hot boundary layer air at transonic speeds should be extended to include the high supersonic speed range.

Combustion Research

By all odds, the most challenging aspect of achieving very fast flight will be the need to release enough heat within the confines of the engine to make effective propulsion possible. Because the same problem is, at this very moment, the principal obstacle to the further increase in the power levels of conventional aircraft turbo-powerplants, it is receiving considerable attention. Yet, however important inquiry into the fundamental nature of combustion may be, and the work being done in fundamental combustion research seems inspired, basic research should not be confused with applied research. It has been demonstrated repeatedly that unless all of the influential factors affecting a particular combustion process are considered during experiment and their effects evaluated with insight and clarity, the results may be interesting and seem scholarly, but they will hardly be useful in the development of practical equipment. There is no question that combustion processes are complex. But, assuming that the ultimate aim of applied combustion research is the improvement of combustion in real engines, it is surprising that, with very few exceptions, the major successes in practice to date stem primarily from empirical methods. This statement should not be misinterpreted as an appeal for a less intellectual approach to an understanding of combustion phenomena in real engines. Far from it—it has been made to indicate a need for a much more vigorous, sophisticated and ingenious attack. It seems that the correct answers to problems associated with intense combustion in rapid flow, in the presence of certain structures and under particular physical conditions, can be found only by experiment wherein the peculiar conditions and circumstances relating to a specific combustion phenomena are critically affected by physical circumstances and other practical deviations from the ideal. There must be wider recognition of the urgency to conduct the applied research under realistic conditions and in such manner that, while utilizing resourcefully the yield of basic knowledge from pure research, it will illuminate the knotty combustion problems confronting the engine designer.

The Outlook

It has always been quite clear that the airframe and the engine are critically inter-related, but few persons even among the well informed have fully appreciated how closely integrated these will be in high supersonic speed vehicles. During the decade starting with 1940, at least seventy-five percent of the advance in the capabilities of aircraft (as evaluated in terms of speed, range, load capacity and reliability) have been due to improvements in powerplant. Twenty-five percent of the same gain can be attributed to improvements in aerodynamic design and structures.

Since then, the contributions of the powerplant to performance have been even greater. The prospects are that this trend will continue because, in the limit, the very high speed airplane will have the physical appearance of a dart. Recognition of these facts already has brought about a significant reorientation in the interests and province of the aeronautical engineer who now is apt to be as much concerned with propulsion machinery as he is with lift, drag, stress and stability.

There is every confidence that high supersonic speed flight will be achieved in the remarkably near future, but the necessary advances are bound to come gradually. Many developments now in progress, intended primarily for application to supersonic aircraft, seem destined for use in very fast vehicles. In that sense the scientific and engineering attack on the impediments to very fast flight is well under way. Apart from the principal problems relating to the design of the fast airframe-engine combinations, will be the many considerations concerning, among other equally challenging items, such things as vehicle controls, air conditioning, personnel safeguards, transparent surfaces if any, operational patterns, and communications. Each of these areas of research and engineering are bound to involve requirements that will seem impossible to meet, but the problems should yield to solution when the proper thought and effort are applied.

There is some likelihood that nuclear energy will be applied to aircraft capable of operating at the very high speeds. But considering the enormous weight of radiation shielding required and a desire to enjoy the operational safety that multi-engine vehicles provide, it is doubtful whether nuclear power will be used until the time that shielding weights are greatly reduced or unless the aircraft were of tremendous size.

A cursory examination of possible configurations for vehicles capable of sustained level flight within the atmosphere, at speeds above Mach 3, leads to some intriguing results. Of course, it is a foregone conclusion that even predictions based on very serious study are subject to considerable error although in the past they have been too conservative. Thus, throwing caution to the wind, it is possible to report as follows:

The smallest manned high supersonic speed airplane may be a pencil shaped object supported on three or four swept-back fins when in the vertical take-off position. Each of the fins will be identical and contain a compound-reheat ducted fan engine. An additional engine may be located at the rear of the main section. Each of the engines will be about six feet in diameter, thirty feet in length and capable of developing a peak thrust of 75,000 pounds. The ends of the jet nozzle will be about 30 feet from the ground at take-off and the overall length of the vehicle will be about 150 feet. Tapering gracefully to a point at the front and to a six foot diameter at the rear, the main section will have a maximum diameter of about 15 feet and a mean diameter of about 10 feet. More than 80% of the vehicle's external surfaces will consist of suppressed apertures for the induction of boundary layer-air. When cruising in level flight, the vehicle will have a slight angle of attack and consume hydrocarbon fuel at a rate of about 75,000 pounds per hour. The aircraft will weigh approximately 250,000 pounds at take-off, carry about 125,000 pounds of fuel and have a maximum range of the order of 3500 miles.

Thus, the outlook is bright with the prospects for safe and economical flight, at hitherto unattainable speeds, within the atmosphere. The possibilities are intriguing, the problems challenging, and the benefits to be derived well worth the effort. It remains for man, however, to use such fruits of his labor with wisdom and to good advantage. END

THE INTERRUPTER

THE BRAGGART

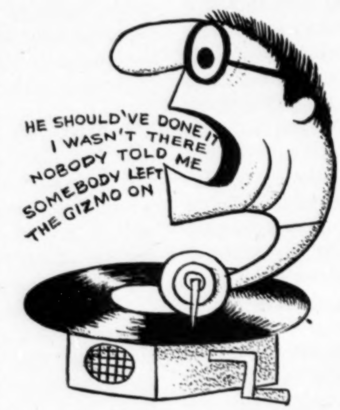
THE CARPING CRITIC

THE MAN-WHO-WO
TAKE-NO

SCAPISTS

THE DREAMER

THE LOAFER



THE EXCUSE MAKER

THE AILING ONE

EUROTICS

THE SCARED RABBIT

THE CHAMELEON

THE BUG ON DETAIL

THE STUBBORN MU

THE FIRECRACKER

THE SOLOIST

THE BELLYACHER

In industry, DP means difficult personality—and the scientific and technical field abounds with them. But most Research Directors, says our Management Affairs Editor, have learned that their departments can't do without the temperamental genius that often characterizes the DP. Here are hints on how to spot his type and how to enlist his loyalty and productive effort in your organization.

THE DP PROBLEM

LUIS J. A. VILLALON

Management Affairs Editor

To the harrassed research executive the initials DP have a far different meaning than they do to the Secretary of State. To the latter, of course, they stand for "displaced persons"—that tragic group which exists in the wake of every major war. To the business executive, however, DP stands for "difficult personalities"—a variety of employee who sometimes seems to make up the bulk of one's work force.

Nowhere do these time-consuming problem children abound in greater number or variety than in the ranks of technical and scientific personnel. Outstanding talent and extraordinary skills frequently seem to come in particularly thorny packages. The Research Director doesn't exist whose problems don't include working with a number of balky, temperamental and/or obstreperous geniuses. The trouble is that often the Research Director must depend upon these very individuals for his best work.

Executives in some areas of industry fancy that they can solve the DP problem by passing out a pink slip whenever the genus comes to light. In the research area, however, where the only thing that counts is brains and background, they know better. Most Research Directors have learned that their department can't do without the DP's. The trick is to learn to live with them, and to keep them productive and reasonably happy.

Even if your particular variety of DP isn't the kind who upsets the rest of the organization, his personality difficulty reduces his effectiveness. Proper handling can, to some extent, offset this disadvantage. But if he's the bull-in-the-china-shop type, lack of understanding and lack of some degree of control can wreck the whole organization.

Not all DP's, of course, can be assimilated peacefully by even the most tolerant organization. Some individuals are so difficult that their cases belong to a psychiatrist—and the executive who tries to function in this area is asking for a couch, himself. And even the Research Department can't afford too many extreme DP's in its set-up.

In a good many cases, however, the moderately difficult employee can be improved through proper handling. After all, almost any trait may be either a help or a handicap, depending on how it is used. It's up to management to provide a

climate in which the DP's behavioral shortcomings will be either minimized or turned to advantage. Actually, many people become difficult personalities because management creates a climate that encourages their being objectionable.

This report is not intended to turn every Research Director into a psychologist: its objective, rather, is to define and distinguish between several categories into which difficult personalities inevitably fall, and give some hints as to spotting and dealing with them. It will supplement the general rules for getting maximum performance from your staff which appeared in an earlier article, *"How's Your Staff Efficiency?"*, (R/E, September 1955, page 30).

Types of DP's

Actually, your scientific DP is not nearly as complicated as he probably thinks he is. He's just an average guy with a moderate over-emphasis of one of three personality variations present in all of us to some degree. Most of what seems to be the infinite variety of complex personalities that make up the average research organization can actually be classified into three groups—the *"fighter"*, the *"escapist"*, and the *"neurotic"*.

The "fighter" is the fellow who, in one way or another, blows his top. His excess of energy sends him all over the shop, pushing, objecting, complaining. In an extreme stage, this kind of behavior identifies the "maniac".

The "escapist" is the sensitive type. He broods. He specializes in feeling hurt, put upon, and in pitying himself. He gradually loses touch with his job, and escapes its real problems by substituting fancied ones of his own. At the extreme stage, the men in the white coats call this one a "schizophrenic"—the person who tries to withdraw into a dream world of his own creation.

The "neurotic" is the man who neither fights nor withdraws. He's an iceberg outside and a volcano within. He usually does nothing outwardly, but his very anxiety delays positive decisions. He's not likely to have the courage to assume either leadership or real responsibility. He's tough to spot because his reactions are more passive than active. Potentially, he's the worst psychopath of all, and less likely to be amenable to good handling.

These three types are perhaps more easily recognized by some of their office nicknames. The genus "fighter" breaks down into a half-dozen or more familiar species. There's the Interrupter, who can't let the other fellow get his idea out without breaking in with two cents' worth of his own; the Braggart, whose slightest triumph is magnified into a new Einstein Theory; the Carping Critic, who is never satisfied with anything that anyone else does; the Pusher, who never lets you forget how late he works, how smart he is, and what a natural he is for a promotion; the Man-who-won't-take-no, who can't imagine that anyone knows better than he does; and the Firecracker, whose short fuse burns up almost more rapidly than it can be renewed, and whose constant explosions leave the rest of the organization in a state of limp exhaustion for days.

The "escapist" genus breaks down into equally recognizable types: the Dreamer is the fellow who much prefers philosophizing on abstracts to tackling a real problem which he might not be able to solve. The Loafer escapes from reality by the simple device of just never getting started on his next job. The Excuse-maker uses a large part of whatever ability he may have in devising elaborate reasons why his assignments aren't completed. Then, there's the Ailing One, who simply gets sick whenever there's a tough nut to crack. And, finally, there's the Soloist, who works so much alone that nobody can ever really figure what he's up to.

Most easily tagged among the "neurotics" is the Scared Rabbit. He spends so much time worrying about whether he's doing right or wrong that he never does anything. A more subtle species of this genus is the Slippery Cuss or Chameleon. He seems to be the model citizen—ambitious, hard-working, and conscientious; but the real key to his personality is compromise in its worst sense. He's the fence-sitter, the phony peacemaker, who really just goes along with the tide. He's just as afraid of decision as is the Scared Rabbit. Two other variations are the Bug-on-Detail and the Stubborn Mule. The former works off his insecurities in over-attention to the things that don't matter; the latter avoids upsetting himself by adopting a position and refusing to listen to any arguments on the other side. The last species we'll mention is the Belly-acher, who relieves his churning stomach with a constant stream of woes and whines, thereby failing notably to contribute to the morale of the group.

The psychologist, who finds most of these business nicknames too frivolous for his tomes, still advises, "Discover what kinds of DP's you have to deal with, and you may get a clue on how to handle them."

Observing the DP in Action

While there is no shortcut to diagnosing human behavior, the most useful single trick in sorting out these three types is observing what an individual DP does when he is blocked. What does he do when he doesn't get his own way? He will probably react predominantly as a fighter, escapist or neurotic. Other facets to watch are the way he gives orders, handles unjustified complaints, dishes out praise, corrects mistakes, and makes changes. These non-routine aspects of business life tend to strip off the DP's thin veneer of normalcy.

The Fighter

DP's in the fighter category react in three entirely different ways when all is not smooth sailing. Your fighter DP may be a sublimator; if he is, he'll take his frustrated energy somewhere else and rob you of its usefulness. If one of your talented engineers suddenly turns into a hot shot on the golf course, or gets overly wound up in community activities, check to see whether something hasn't interfered with the expenditure of that energy in his job. On the other hand, he might be a compensator. This is the least undesirable reaction, since blocking in one direction simply determines him to be good in some other phase of his job. Then, there's the plain, ordinary aggressor; he just puts his head down and takes out his frustrations on everybody around him, usually both at home and at the office. He's the worst DP in the fighter group. His associates dislike him, and they lose respect for the boss when he puts up with him. He's really bad news for organization morale.

Well, what can you do about a fighter DP? You probably can't change him to another type, but you can minimize the chances of letting undesirable reactions get in the way of his work—and you can cushion his effects on the rest of your organization.

In the first place, make sure that he has enough—and large enough—challenges. Remember, he's the one with the energy and the ambition, and a large part of keeping him out of mischief is in giving him enough things to do in which he can shine without bragging.

You can't give him a swelled head, because he usually has one already. Therefore, it helps rather than hurts to keep assuring this type of DP that he's good. What you're trying to do is to convince him that he doesn't have to assert himself all the time to impress you. The piece of advice, "Stop pushing, the door is open," can't be quoted too often to this fellow.

Once you've done these things, and if you still have trouble, don't hesitate to be blunt and to show authority. The fighter DP, for all his independence and bluster, is usually ambitious enough to have a healthy respect for authority. If you put it to him straight, and explain that you wouldn't bother if he weren't potentially such a valuable man, he'll probably react favorably.

Often, it isn't worthwhile to try to dampen a Firecracker's fuse. Sometimes, it's better policy to insulate those around him from its effects. If the Firecracker is robbed of this outlet, he may develop far worse habits. One of the most useful techniques is to try to find out why he's so short-tempered and explain it to those around him. The secretary to the head of the statistical organization had trouble with a disagreeable vice-president. Once she learned, however, that his wife was a permanent invalid, his gruffness stopped bothering her.

As a matter of fact, one of the most important things to do in dealing with this kind of DP is to periodically restore the ego of the people who have to work around him. The fighter type is often the most useful person in the whole organization, but his forcefulness is likely to wear down his associates.

The Escapist

The escapist shows his true colors when blocked, too. When this type isn't reasonably satisfied in his work, he's not as much of a nuisance to others as is the fighter, but he himself becomes almost entirely ineffective.

He may do just enough to get by; figuring he can't compete, anyway, he loafs on the job and lets his mind carry him as far away as fancy takes him. On the other hand, he may actually try to hold up the show—consciously or unconsciously—and, at the same time, attempt to blame his fellow-workers for the delay. He retreats into excuse-making and rationalizing.

Sometimes, he escapes into chronic illness—anything from a headache to a backache—and turns himself into the kind of DP problem that a budget-conscious or short-staffed boss *must* solve.

The most important thing to remember in working with the escapist DP is that he is sensitive or insecure. The only way to keep him on the productive track is to build him up and avoid hurting his feelings—if he's valuable enough to make the trouble worthwhile.

Take time to notice him, confer with him, so he won't imagine slights. Let him know you know he's there, even though he is the quiet, retiring type. Try to discourage his excuses by giving him a graceful way out when he makes a mistake. Ask for his opinions, and help to draw him out of himself.

Here again, of course, there comes a time for sterner measures. The excuse-maker can only be converted into a person who faces up to a mistake or failure by fixing responsibility in such a way that it's difficult to dodge or pass on to someone else. And instead of getting angry at excuses, which is what he really expects, fool him by taking the time and sympathy to show him how the job really could have been done.

Neither the confirmed loafer nor the hypochondriac can be considered curable by usual methods. Unless there are useful jobs to be done, so routine that they do not drive these types of DP's into escapism, these two might as well be considered dispensable.

The Soloist, on the other hand, although falling in the same category of human behavior, may not be any problem at all. If the only thing he wants to escape from is other people, he may be more industrious and creative alone.

The Neurotic

The first two types of DP's do *something* when blocked; the neurotic just sits tight. He fails to make any decision to act. And the trouble is, he can be extremely clever at hiding the fact. Posing as the departmental peacemaker and the most reasonable of men, he may well retard any positive moves and, at the same time, slow up the people under him, since he doesn't want them to stick their necks out, either. He's hard to spot because his protective coloration is so excellent.

Common sense remedies, however, apply to some of the various species. The Bug-on-Detail should be loaded up with more work than he can possibly handle, and then, just at the breaking point, be shown which parts of his efforts are really applicable to job goals. The important thing about the Slippery Cuss, or Chameleon, is to recognize him. If the boss sees him as clearly as do most of those around him, he can do many a useful job without being expected to make policy decisions.

The Belly-acher, a victim of his own nerves, is never going to be satisfied, so there's no use wasting time in trying to improve the conditions about which he complains. He and the Stubborn Mule are two kinds of neurotics who are almost impossible to deal with.

Those in the neurotic class are the real, potential psychopaths and if pushed too hard, are likely to get worse rather than better. Yet, it is their presence, often undetected, that weakens many an organization.

Conclusion

The methods mentioned above are, of course, only a few samples of practical ways of handling DP's. Actually, once the type is recognized, the boss' good common sense will usually suggest ways to minimize the difficulty. The problem is that, too often, the DP is laughed off as an irritant or discarded as a misfit.

With the present shortage of scientifically-trained personnel, however, the Research Director can accept neither of these courses. He must get maximum productivity out of those people he is able to hire—and trained and educated minds are too scarce to make minor aberrations cause for discharge.

The Research Director is fated to deal with Difficult Personalities during all his executive career. Here, as in all other areas of analysis, the most important steps are classification of the species and diagnosis of the problem. From here on, the solution depends largely on ingenuity and common sense.

Remember that unconventional approaches to the solution of engineering problems often come from individuals who are unconventional in their relationships with people and their attitudes towards their jobs. END

Economics Research in Development Programs

Want to know what industrial economics research is, how it fits into the overall research program? This article contends that it's not a particularly abstruse science, that results depend upon the same sound principles as research in other areas. The pay-off: better analysis of research opportunities, increased objectivity in setting research goals, more ease in selling the research program to company management.

JOHN RIVOIRE

Applied research problems always have economic aspects. Money is the only common denominator for materials, skills and all the other inputs to the research process. It follows, then, that economic evaluation of applied research is management's chief guide to its success or failure. Therefore, the researcher in any of the physical sciences should appreciate how his results balance against their money costs.

In the economic phase of research this concern with inputs and outputs is even more pronounced, since it frequently deals with analysis of industry and area structures to develop profitable production and sales opportunities. But such studies are not confined to economic analysis of production and sales alone; scope, direction and results of the overall research program should be considered as well. In this light the function of economic analysis becomes increasingly important as the research program of a company grows either in absolute size or as a proportion of the company's activities.

This article is primarily concerned with the scope, method and uses of industrial economics research as practiced by independent research organizations; but the principles outlined apply as well to large research undertakings in all types of organizations. Economic analysis has real value as part of an overall research and development program in those organizations not concerned with research as a primary process. Its value to the research director and company management depends upon the extent to which it is integrated into the whole research program and the closeness and continuity of its interaction with the technical phases of research. This article will attempt to show why it should be included in the organizational framework for research and why it should be part of the thinking of all professional people in the research unit.

Awareness and interest in the economic phases of research is not enough, by itself, to insure that this phase of the total research process is accomplished. A group of specialists with economic training as well as technical background is needed to investigate the economic aspects of all problems under study and advise research management of its findings. Such a group can make a unique contribution to the research program by insuring that inputs are balanced against outputs and that time and money are not wasted on unprofitable projects. Similarly, the economics research group can point out areas where further study may be warranted.

Three Basic Areas for Study

Research in industrial economics centers around three basic types of problems:

- Size and nature of the market and definition of the marketing process—usually called *market research.*

- Study and definition of manufacturing, materials handling, paper work and other processes—usually called *process analysis.*
- Problems involving economic development—studies looking toward industrial growth.

Market Research

Market research can be one of the most important activities of an industrial economics group. Sometimes the problems are primarily of a marketing nature, e. g., to determine market coverage or efficiency of distribution. All such studies have technical aspects, even where primary emphasis is on consumer behavior. Most market research projects, however, deal with problems in which technical information is of considerable importance.

In market studies dealing with industrial products, the market researcher must always be aware of the technical implications and limitations of his work. To develop information on the market for gray iron castings in a certain area, for example, the market researcher should know something about the processes and process costs involved, applications for gray iron castings, and their advantages and disadvantages compared to competing materials. Again, the problem of estimating the market for a pump requires the ability to develop and visualize all uses to which the product may be put, the suitability of these uses, and competitive advantages and disadvantages.

The influence of technical considerations is by no means negligible in market research on consumer products. For example, good technical knowledge of the qualities of a new baking powder, a new seasoning ingredient for foods, or a new household cleanser is of great value to the market researcher in these fields. It is difficult to overestimate the value of technical information in a new product development study. Here communication and feedback between marketing and technical people is vitally important.

Process Economics

Process economics is traditionally a part of engineering. In many process studies, however, the technical engineering aspect is minor while economic problems assume the dominant role. Thus major responsibility for research of this type falls squarely within the sphere of the industrial economics group.

Take a problem involving the most economical method of moving and storing goods within a warehouse, for example. No engineering design or other strictly technical problems are involved. The physical means of carrying out the job already exist. Determining optimum combinations of space, product equipment and manpower are the real problems—problems in which economic content considerably outweighs engineering content.

Even though the engineering aspects of a research problem in industrial economics are usually subordinate, engineering is by no means negligible in every instance. In designing a warehouse system, the number and size of objects to be moved, distances they are to be moved, design of equipment and necessary layout must be considered. Engineering deals with the physical means of accomplishing these things, but within a framework designated by economics. Only rarely is the engineer free to design a piece of equipment to do a job with no regard for cost.

Product Development

Engineering knowledge is also important in product development. Independent research organizations are often asked to determine the market for a new product when only a crude prototype exists. Staff engineers can tell what the model is capable of doing and what its possibilities will be when it has been redesigned.

An automotive products manufacturer recently came to a large independent research organization with a problem

of this nature. Through an inventors' council, he had been offered an option on a new product—a simply-designed pump with low operating cost. But since performance level was low he asked, "Will it be worthwhile for us to extend the option on this product and spend time and money developing it?" A brief analysis of the markets available for the pump showed that it had profitable commercial possibilities. As a result of this preliminary study the manufacturer decided to launch development work, agreeing that he would return to the research organization for further market and engineering advice.

Area Studies

The third major sphere in which the industrial economics group works is Area Studies, a group of activities consisting of industrial development, input-output analysis (developing industrial balance in an area) and related analyses aimed at establishing the economic characteristics of a region.

Application of input-output techniques to economic study of a region shows what can be done in adapting an analytical tool to program planning. For example, the Chamber of Commerce of a large city in the midwest became concerned about its industrial development problems. An independent research organization was asked to determine the city's existing industry pattern and to submit recommendations based on the analysis. As a result of this study, the area surrounding the city was found to be "deficient" in some industries (that is, area production did not equal area consumption). On the strength of this analysis, the Chamber of Commerce set up a long-range promotional program designed to attract specific types of industries to the area.

Another phase of this kind of work is analysis of specific problems involving use of area economic data (for example, availability studies of various raw materials). Logically this leads to specialization in the economics of natural resources and resource development. Location studies are still another example of this type of research.

Many phases of economic research cannot be fitted neatly into the three basic categories. In some instances, the work combines elements of all three, or involves in addition heavy emphasis on psychological factors.

Staff Requirements

Because industrial economics research is still largely in the "skilled craftsman" stage, staffing problems assume even more importance than in the ordinary research operation. Knowledge of economic research techniques and sources of basic data are indispensable requirements for economists engaged in industrial research. Thorough grounding in statistics and knowledge of industry organization and relationships are desirable, as well as the ability to examine masses of data and preliminary conclusions which often conflict. Finally, the industrial research economist should be able to arrive at conclusions which can be presented logically and justified by the weight of evidence. This ability requires an analytic and judicial mind as well as knowledge of the basic functions and processes of economic research.

Specialized knowledge of industry or area operations is particularly valuable. Ideally, this should be gained through intimate association, over a long period, with important operating problems of the industry or area. Some of the best researchers in industrial economics have technical training and an industrial background, gaining their economic proficiency on the job. Where technical and economic knowledge are both important, training and background should be primarily technical since competence in this area is probably more difficult to develop than economic knowledge.

Operating Methods

Industrial economics research rests squarely on five main procedural points:

- Defining the problem and planning attack
- Accumulation of data
- Analysis of data
- Presentation of findings
- Follow-up

These five steps were well illustrated recently when a manufacturer presented an independent research organization with an idea for a new product which existed in laboratory quantities. Product features had already been determined by laboratory evaluation and by testing in the processes of several potential users. The problem was to determine:

- What market existed for the product at the proposed quantity price?
- How the product's sales potentialities could be developed?
- How the product should be marketed?

The research organization submitted a proposal to the client setting forth their formulation of the problem, showing a method of attack, elapsed time from start of the study to delivery of the final report, and total cost of the proposed research. This data gave the research organization and its client a basis for agreement on objectives and methods, a yardstick for measuring research accomplishments.

Data on rates of use, economics of the consuming industries, information on competing products, and other existing data, both technical and economic, were gathered, collated and analyzed. The gaps were then filled in through personal interviews with potential buyers. The sum of this information was analyzed in detail and a final report presented showing the answers to the problem questions.

Although the contractual responsibility of the independent research organization commonly terminates with acceptance of the report by the client, follow-up is usually desirable. In this instance a continuing relationship was established in which the research organization consulted with the client after introduction of the product, aiding him in marketing problems arising from his application of the research findings.

Follow-up is just as important when the entire research program, including its economic phases, is carried out within a company. Company management is the client and the economic research section acts as the counterpart of the outside research agency.

Specialization Versus the General Approach

A need for specialization exists in the field of industrial economics research as in other research areas. For example, the economic problems of agriculture are decidedly different from those of the tire or automobile industries, and the data relating to these industries differ widely. Again, consumer market research differs widely from industrial market research—not necessarily in objectives sought but in guiding principles and techniques. Each area of specialization, however, should be an integrated family of problems if the specialist is to do his best work.

No problem falls entirely within the confines of one dis-

cipline; information and techniques developed in one area can be of great value in another. Thus, two needs are apparent if research in industrial economics is to be effective:

- Economic and technical specialists must cooperate closely; each should be aware of the major goals and methods of the other.
- Coordination requires an individual with a broad knowledge of both areas. This facilitates interpretation of the respective goals and insures that both groups of specialists work effectively as a team.

Industrial Economics in General Research

The industrial economics group undoubtedly belongs in most general research organizations, for economic problems are inevitably encountered in conducting research in the physical sciences. Since research is the major product of such organizations, it is vital that results meet the test of economic value. A good case can be made for closely relating economic research and research in the physical sciences in all types of organizations. For example, the large company with a highly developed research function might profitably re-examine its entire research program, particularly the relationship between research in applied chemistry or physics and research in markets and marketing problems. Placing these functions in the same household can contribute a great deal to improving the quality, timeliness and results of both kinds of research.

For optimum results, the economic viewpoint should be applied at all points in the research and development process. Economic skills and economic judgment should be represented at the top level of research management, possibly in the person of a staff assistant to the head of the Research and Development Department. The research organization may also include an economist (or group of economists) whose duty it is to investigate the economic possibilities of all large research projects before they are initiated. They may also recommend areas in which research is likely to produce the greatest economic gains. In addition, engineers and other technical personnel may be trained in the rudiments of economic analysis—inculcating an appreciation of the economic viewpoint of research. In other words, technical personnel should realize that every research development must meet economic as well as technical standards.

Organizing and orienting the research department in this fashion can insure that the most profitable opportunities are pursued. Conversely, it will help to avoid expensive mistakes. Establishment of an economic evaluation group and formalization of economic research and analysis procedures will help the research director to proceed further and faster toward his objectives than he might otherwise do.

Expansion of Research in Industrial Economics

A great expansion in industrial economics research is due in the near future, primarily because the importance of market and other economic research as a specialized activity is beginning to be widely recognized. Also many companies are committed to expansion, resulting in review of product lines, analysis of market potential in new or neglected products, and review of other possible expansion activities. Still other companies are interested in retrenchment, cost cutting, and reorganization of production, handling and methods. Industry specialization and diversification is another focal point around which future economic research programs may center. **END**

An R/E Survey

Melvin Mandell
Associate Editor

Upgrading Technicians

More R/D Managers Are Doing It

Proper handling of technicians can ease your engineering manpower shortage. Here's a survey of upgrading techniques and policies that have worked for some R/D managers.

"One good technician is worth half an engineer." This near axiom offered by a senior engineer with a large design firm indicates how much proper utilization of technicians can help relieve the shortage of engineers. Many companies engaged in research and development are devoting increased thought, time and money in an effort to keep their technicians satisfied. Their experiences in upgrading technicians will help technical management in both large and small companies to formulate a viable policy for their own non-professional lab personnel.

What is a Technician?

Some organizations consider anyone in the lab who does not have a bachelor's degree a technician. General Electric Company designates those employees who have graduated from two-year technical institutes, or who have equivalent experience, as technicians. The accepted definition of a technician is a man or woman who directly assists engineers or scientists in research and development work and who also has some comprehension of the technical nature and significance of his work. This definition *excludes* draftsmen, clerks, secretaries, technical writers and editors, and blueprint-machine operators.

Typical titles for technicians are: junior technician, senior technician, junior aide, senior aide, research assistant and laboratory aide. For highly experienced technicians who will never reach professional status, Westinghouse has created the title of "technical associate". The highest grade of technician at Bell Telephone Laboratories is called "senior technical associate". Other companies can expect pressure from their technicians for better-sounding titles to go with their greater technical responsibilities.

Sources for Technicians

Most companies hire technicians as needed by simply placing advertisements in newspapers. Others go to local technical schools. A group as small as American Machine & Foundry's Springdale Chemical Research Laboratory can often find technicians simply through personal recommendations of present employees. Reynolds Metal Co., Louisville, Ky., recruits lower-grade technicians from among its other non-technical employees. When an organization is as large as General Electric, however, it must use high-powered recruiting methods comparable to those that are successful in engaging scarce engineers. According to a talk by GE's Dr. L. E. Saline at the recent Engineers Joint Council General Assembly in New York, GE maintains a list of about 50 approved two-year technical training insti-

tutes throughout the nation. Recruiters find these schools a major source of technicians and visit them regularly.

Salary

The highest salary for technicians reported was $740 per month—at Bell Telephone Laboratories, Inc., New York 14, N. Y. This figure is even higher than the top of $125 per week noted in a study of the classified advertisement section of recent issues of the Sunday *New York Times,* the largest employment ad section in the country. In general the top salaries for technicians reported for chemical research and development groups was lower—about $100. However, AMF's Springdale Laboratory makes up for a lower top by refunding the entire tuition fee for any schooling taken to improve work skills. Beginning salaries average about $60, and range from $50 to $70 per week. All of the companies queried by R/E reported that their technicians receive merit raises.

Women in the Lab

Reynolds Metal is the only firm queried that encourages women to be technicians. Although some women are presently employed as mathematicians or experimental tube assemblers, only the chemical laboratories employ female technicians to any degree. The converse is that few women apply for jobs as technicians outside the chemical research field. Pay is one reason. Women believe that industry pays them less than men for the same work. R/D managers who hope to use women as technicians may ease their recruiting problem by indicating that they pay women as well as men for comparable work, if that is the policy of their company.

As computers are used more extensively in solving research and design problems, industry will undoubtedly need more programmers and mathematicians—both in the technician category. Women are well suited for this work and should be in demand. Many women are used for such work at Bell Telephone Laboratories. About 14% of the technicians there are women and more are desired.

Reaching Professional Status

"Years ago many engineers did technician's work. Now many technicians do engineer's work." This statement by Howard J. Gresens, director of personnel for Airborne Instruments Laboratory, helps explain the demand of many technicians for professional status. A number of technicians are men who originally hoped to become engineers. Either through lack of opportunity, military service or financial pressure, they did not start or complete schooling leading to a bachelor's degree in engineering. Many of these men still hope to become engineers and are taking night courses towards that goal. It is common practice in most companies to refund 50% of the fees for such courses, although some are already refunding 75% and even 100%. In a few years competition may force all companies to pay the entire tuition fee for technical courses.

At Westinghouse's Air Arm Division a definite distinction is made between those technicians striving for professional degrees and the others. The former are called "engineering aides". A number of technicians at General Electric Company have become engineers with degrees and some have risen to high supervisory positions. When a technician at Bell Telephone Laboratories receives an engineering degree, he is reassigned to work in a new department rather than with the engineers he formerly worked for.

Under the regulations (Part 541, July, 1954) of the Federal Wage and Hour Administrator an employee without a degree may be given professional status "exempt" from the requirements for over-time pay if he does creative work and makes more than $100 a week. With the shortage of engineers, many technicians have been given creative tasks or duties that were formerly done by engineers. These men would like to achieve exempt status despite the loss in over-time pay privileges because their possible top salary limit is much higher.

Two companies have programs for qualifying technicians as engineers. Airborne Instruments Laboratory based its "Engineer Qualification Review Committee" on a program in operation at Federal Telecommunication Laboratories, Nutley, N.J. At Airborne, technicians can make application for upgrading after one year of employment. The committee, made up of four experienced and carefully chosen engineers, first interviews the applicant's supervisor. If the supervisor indicates that the technician has the ability and potential and can represent the company in the field, the committee gives the applicant an oral interview. Challenging questions are asked that require an application of engineering principles. At the end of the oral test, the technician is given an engineering problem in his specialty. As much as a month or more may be taken at home in answering the question. The technician can consult textbooks, but he is put on his honor not to receive help from any engineers.

If the technician passes, he is immediately reclassified as an engineer. His salary is converted from a weekly to a monthly rate usually without an increase. Out of a regular complement of 75 technicians, eight men have come up before the committee since the program was started in 1952. Only four passed. Their fellow employees have accepted these men as engineers and the Wage and Hour Administrator accepted them as bona fide engineers. Two of the four have left Airborne to join other development groups, and were accepted as engineers. Significantly, all four men were less than 30 years old when they qualified.

According to Mr. Gresens, the qualification program has had a fine effect on the morale of the company's technicians, even if it hasn't raised their level of training. All the vague complaints about "doing an engineer's work and not getting paid for it" have ended. Airborne's qualification program could be a model for an industry wide program that would help keep technicians from leaving industry for more lucrative but less creative jobs such as TV repairing.

Company Training

A little simple arithmetic shows why companies often have to give newly hired technicians additional training in technical fundamentals on company time, as distinct from voluntary after-hours schooling. About 14,000 technicians will be graduated this year from the nation's technical institutes, contrasted with 23,000 engineering graduates. Using the average figure of two technicians needed per engineer, there is a shortage of 46,000 minus 14,000 or more than 30,000 technicians. Some of the gap, however, will be made up by well-trained men leaving the armed services.

Most company training is on an informal basis. However at General Electric Company there are formal courses given in technical fundamentals. Most of these courses are

taken during an "orientation" period. The newly hired is given a three months' assignment. If he likes what he doing, he stays in that department. If not, he is assig to another department for three months. Generally, tw three such assignments are sufficient to settle a man to satisfaction. The unusual policy of sending excepti technicians to specialized schools with all expenses p including salary has been adopted by Reynolds M Company.

At Westinghouse's Air Arm Division in Baltimore, orientation period is much shorter. A newly hired te nician is first assigned to a test area or the instrum room. Close supervision gives some idea of the man's ca bilities and he is then assigned to a project. Few small co panies can afford the luxury of an "orientation" period formal courses in fundamentals. They simply hire a qu fied technician for the job as the positions become availa

Relations with Engineers

Generally technicians are regularly assigned to work w one engineer or scientist or one team of professional p sonnel. At both Westinghouse's Air Arm Division and ternational Resistance Corporation a pool of technicians also maintained for assignment where needed. Westi house finds that on the average the individual engineer supervise two technicians profitably, but in some cases work with up to five, six or seven. N. Rubinfeld, a se engineer with W. L. Maxson Co., reports that he can k four technicians busy supporting his design work. At A borne Instruments Laboratory, many engineers super four or five technicians, and some technicians super other technicians. At Burndy Engineering, Norwalk, Co usually only one technician is assigned to each engine

Dr. Saline of GE feels that greater efforts must be m to train engineers to better understand the relationship tween themselves and the technicians and how to best sup vise technicians. None of the companies reported that formal efforts are being made to train engineers to uti technicians better. Dr. Saline also called for training gineers in delegating responsibility to technicians, but one organization, an electromechanical development gro reported that it is having any difficulty in getting its e neers to assign responsibilities to technicians.

Where Do We Go from Here?

Technical management can expect to hire more and m technicians as the shortage of engineers grows. Many the technicians available will have considerable train and experience. Since these people will be given more c tive and profitable work, they will undoubtedly dem more recognition and higher salaries. Because of the gr ing investment in each technician, management will h to offer increased inducements and benefits (such as trips technical meetings) to lower turn-over and attract o technicians. And engineers will need counseling in how best handle these valuable and expensive employees.

Larger companies will be recruiting more actively technicians and will be giving them more training; sma firms will simply have to raise the ante. To a lesser deg the problems of management in hiring, motivating keeping engineers will be duplicated with technicians. in the light of the proven gains that an alert, happy creative technical staff can make for an organization, problems are well worth being met and solved.

Research Administration

MERRITT A. WILLIAMSON

This is the season when winter recedes and spring blossoms forth in all its glory. This is Nature's creative season, and we see the results of this creativity everywhere. This is the time in many research laboratories when reorganizations are rife. The new look at plans for the new year and the optimism of New Year's have had their luster dulled. One suddenly realizes that a quarter of the year is gone and the pressure to get things moving faster mounts. In this pause for breath and contemplation induced by early spring, managements have an opportunity to take a look at operations. And frequently they find things not entirely to their satisfaction. Perhaps, then, it is appropriate that we consider reorganization and some of the factors involved.

There are levels and degrees of reorganization. When a technician is transferred from one project to another this is reorganization, although of a minor sort. When a project engineer concludes his project and the working team is broken up, personnel must be regrouped if the laboratory is operated on a project basis. This represents another level of change. Again, if the laboratory is organized on a functional basis by fields of science or specialization and it becomes necessary to replace a group, section or department head, or to split up a large division into finer subdivisions, reorganization is again involved. The problem of replacement by promotion from within or by outside hire appears. Then, too, if a Director or Manager of Research, or a Vice President, is replaced, reorganization is almost sure to follow and becomes a matter of concern to everyone in management and to everyone in research.

Reorganization at any level is not merely a matter of shifting names in boxes to make a more logical looking pattern. It is more than grouping persons with similar interests, by areas of specialization, or by projects. An organization chart, as Arthur D. Little once pointed out, should not be confused with an organization. Some laboratory managers don't believe in charts and they won't construct one. Others have their organization charted to the exact position of each technician. Is there any difference in the effectiveness of their organizations as related to the document called a chart? Or, on the other hand, does a *real* organization actually operate, sensed, realized and cooperated with by all concerned? How does one in authority achieve such esprit de corps?

For what it is worth, it seems to me that the closer to the actual laboratory work one is, the less one has to be concerned about a formal chart. If you have a project leader or a section head who follows closely the work for which he is responsible and who is constantly available for advice and guidance, no worker should have to raise the question of whom he reports to and from whom he should take orders. A leader has been defined as one who can get people to do what he wants them to although he does not have any direct control over them. If you have a project leader who can get other groups to help him without resort to the next higher echelon (to borrow a term from the military) mark him well—perhaps he is due for a promotion.

Spelling Out Responsibility

As one gets further from the bench, assignment of responsibility is needed. In my opinion, much of the confusion, rivalry and duplication of effort in organizations stems directly from a failure to spell out just who should do what. It may all be clearly etched in the mind of the research director. But unless there is a general understanding among the staff, confusion runs rampant and the worker best equipped to "free-wheel" soon moves into areas where he has no license. On the other hand, who can argue with him when no limit exists? In time the result is first, disorganization, and second, reorganization. A man may be terrifically inspiring at the project engineer level, but very disappointing when moved to a higher level. In a small group, a change of plan has but to be mentioned to one person and it permeates the work force. But the same technique applied higher in the organization fails to work because the opportunity for relaying the word does not exist, nor is there a personal incentive. When your organization doesn't seem to get the idea, doesn't coordinate, and doesn't know what is going on, do you blame it or think it is incompetent? Or do you examine yourself and discover, perhaps, that you never did let your people know what was in your mind at the same time and with the same emphasis? I think people on the whole want to please their supervisors. I further think many of the reorganizations are futile in that they do not accomplish the desired integrated team effort. Reorganization of the external world under your control can be seen, but the critical step may be the reorganization of yourself. I would like to submit that reorganization may really be the result of expressing creativity on someone's part who is too far removed from the bench to obtain satisfaction in this area normally.

Organization as Division of Labor

Organization inherently implies division of labor. I am sure most of us readily see this when we look at a chart. If we draw vertical lines we separate the diagram into areas reflecting division of labor by fields of endeavor or by project. But how many of you have thought about the fact that horizontal lines of a chart dividing division, department, section, group, etc. is also done to achieve a

division of labor? Yet this is true. When you are in one level it is inappropriate to do the work of the next lower or higher level. Organization into horizontal levels is a division of labor.

In careful planning, we take care to delineate these areas. They can then be separated by vertical lines. However, I do not believe that enough thought is given to a division of labor by level. When an organization is recognized as not being efficient, a reorganization is usually made. Thinking is generally clear in the separation by areas, but how often are the levels altered? Of course, there is good reason to be wary in this direction, for mistakes made in this realm are difficult to rectify. When reorganizing, however, a little thought along these lines may prevent the establishment of a situation that cannot be handled equitably later. Get in the habit of thinking of division of labor horizontally as well as vertically and make sure that no one advances to a different job unless he is prepared to and can handle the work appropriate to that level.

Most organizational problems are of a very extensive and complex character and require considerable specific background to permit selection of a course of action from the alternatives presented. We have, however, an interesting case in a limited area for your discussion. Let's see what we can do with it.

Frank Davis' Dilemma

Frank Davis is a Section Head with responsibility for three important projects. Two of his projects are organized satisfactorily under two project engineers who work well with him. They also cooperate well with each other in any areas of overlapping interest. His problem is with the third project. This work, of a more complex technical character, was started out under Bill Eaton as a minor effort. Frank did not give it project status as it involved only five engineers and five technicians. Bill was, therefore, not formally a project engineer. However, the initial work was so successful, that an extension and enlargement of the project was proposed and approved by management who immediately gave it a high priority.

Bill is an exceptional man in his highly specialized field which requires a high degree of creativity. He is, however, uniformly disliked by his men because of his rude and sarcastic manners. They work along with him more or less amicably because his boss, Frank Davis, handles most of the administrative work and is close to the men and understands their position. They know that he, rather than Bill, is responsible for their performance reviews and salary adjustments. Frank is well aware of Bill's relationship with his men but sees him from a different point of view as his supervisor. He considers Bill a basically fine person—erudite, sensitive, highly intuitive, and of good humanitarian instincts. Unfortunately, however, these good points do not show in dealing with the engineers under him or with the other two project engineers. That he rarely comes to violent disagreement with Frank is largely because Frank recognizes Bill's abilities and makes allowances for his weaknesses which are most likely due to ulcers and a diabetic condition. These physical disabilities, in turn, contribute to his lack of patience and his constant irritability. Bill makes no allowances for others about him and lashes out frequently with caustic comments which, of course, are not well received.

Alternatives Open to Frank

Because of the newly established importance of this project and its formalization, Frank feels it necessary to have a project engineer to handle the administrative as well as the technical details, since he is spending an inordinate amount of time on Bill's project to the detriment of the other two projects under his jurisdiction. Several alternatives are open to him. He could promote Bill. Certainly Bill's length of service, his company loyalty and his technical ability all indicate that he deserves the prestige and recognition of the title which he knows Bill wants desperately. He hesitates because of Bill's limited ability to deal with people.

A second alternative would be to bring someone else in over Bill, probably by hire from outside since probably no one within the present organization would want to take over supervision of Bill if they were already at project level. If they were not already at that level, Bill would resent it so much that the incumbent would be in an untenable position. Frank knows that Bill would resent being passed over in any event, and feels that he might leave, thus seriously handicapping the project. Also, it would be difficult to find a man of a technical competence whom Bill would respect.

The third alternative as Frank sees it is to leave the situation untouched. This has drawbacks because he feels it is not right to neglect his own job as Section Head by the demands this (existing) situation creates. Also, he thinks that Bill would not be satisfied to continue indefinitely without a promotion. He has already told Frank he thinks he should be made a project engineer. Frank also fears the already poor morale of Bill's group will become worse unless some relief is obtained.

Forum

What sound management principles are applicable to this case? What other alternatives exist? What should Frank Davis do? Write us your solution being careful to state any assumptions you make or data you add which are not given in the case. Let's see if we can get Frank out of his dilemma.

(Please address your replies to Dr. Merritt A. Williamson, c/o Research & Engineering, 77 South Street, Stamford, Conn.)

Discussion of Mr. Colt and Mr. Fenn

I was very gratified with the quality of the returns and, as I expected, there was no unanimity of opinion among the discussors. This was to be expected since every person views the situation against a different background. More persons leaned toward Fenn's methods generally, for in research work, as Thomas A. Treglia of the Army Chemical Center pointed out, "If active interest in the program cannot be stimulated, no amount of regulatory action will produce full and efficient effort from the personnel". He further warns that too strict and exacting regulations are apt to result only in a "cat and mouse" game wherein the workers generally are able to circumvent rules and will waste much time finding ways to accomplish this. There was a feeling that as one progressed toward applied research, the Colt type of supervision was to be preferred.

R. M. Brick, Director of Metallurgy for the Central Research and Engineering Division of Continental Can Co. said he was a Fenn for ten years while directing university research and has become a Colt now that he is in industry. He believes that the Colt method is the better with certain modifications.

He believes, for example, that when certain experiments require workers to stay beyond the normal quitting time they should be permitted to come in late the next morning without criticism. He adds that Colt should encourage professional activities (attending meetings, presenting papers, etc.). His third point was the encouragement of technical seminars run by the men themselves. (Let's have some reader comment on this subject).

Comments on Professional Status

An interesting contrast was presented in discussion of the staff's complaint about loss of professional status under Mr. Colt. One writer cited surgeons who get to the hospital three days a week to scrub up for operating at 7:30 a.m. They don't feel they can come and go at their pleasure. Predominately, however, there was sympathy with their complaint; E. H. Kinelski, with International Nickel Co.'s Research Laboratory, pointed out that without being able to act as a professional, little opportunity exists for research workers to develop any administrative experience, hence their promotability might be blocked. A comment by Albert G. Haynes, Project Engineer for the Plastics Division of Oscar C. Rixson Co.: "Good professional men, at heart and mind, have no necessity for shop rules and won't tolerate them long." This same writer stressed the fact that Colt's system was to be advocated *only* "in situations where there is a very mediocre or lower type of engineer or other person of professional qualifications without the mental and moral character to abide by professional ethics."

The "Middle Course"

With regard to following a middle course between Colt and Fenn, it appeared to be acceptable or not depending on one's conception of a "middle course". One writer would improve Fenn's system by having him spend more time with the men in the department (acting as Colt does in Item 3). Another (the one who has been both Colt and Fenn) states that Colt might relax supervision a little and Fenn tighten his, but the true middle ground is too dangerous. Reasons? "There are some rules but not enough. Personnel can never feel sure of where they are, whether a given action oversteps or doesn't overstep an ill-defined boundary . . . it is hell if the umpire can invent a rule at his pleasure!" Still others stress that both Colt and Fenn are in error if they pursue their uniform policy of supervision for each and every person under their direction. The method must be adapted to both the personnel and to the conditions existing at the time.

Should research personnel be treated differently from other workers? One writer points out that they, of course, deserve the same fairness, courtesy, consideration, recognition, etc., but they also require different stimuli for the happy execution of their jobs as compared with production workers. One comment: "Engineers, scientists, physicists . . . are not amenable to dictation; direction (however) is a normal situation when . . . properly given".

From the professor turned industrialist (the Fenn turned Colt), we have some statements which are food for thought. ". . . I feel that while the Fenn method is better for university research, I would confine it to that sphere. There were always roughly half of the men who were low in productivity under the loose Fenn-type of supervision, either because of laziness or lack of top notch ability. There will be somewhere near the same proportion of men of the same type in an industrial organization, men unproductive under Fenn but productive under Colt. Colt not only gets more out of his men, but he comes to know them much better."

Comments on Management Principles

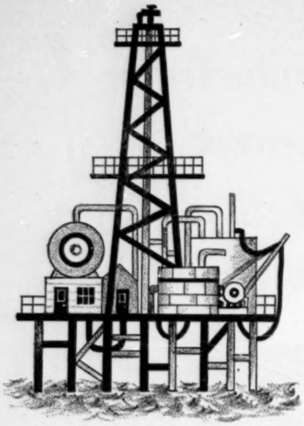
Now with regard to the principles of management, the following three comments are certainly worth careful thought:

"Projects and programs are uniformly inanimate and are thus subject to uniform regulation; personnel conducting projects are individuals and subject mainly to individual regulation."

"A good executive will have the ability to delegate responsibility and authority to his subordinates appears to be the main principle involved. However, it is also the responsibility of the executive to his management to get the work done, even if he has to resort to dictatorial methods to accomplish it."

". . . the best basic rule in every case is the Golden Rule of biblical fame." END

Scientists probe ocean depths for clues to oil wealth



Underwater Research

As part of a research project to develop better ways of finding oil both on land and underwater, a team of Socony Mobil geologists conducted an underwater research expedition in the Gulf of Mexico. The scientists studied the sediments deposited on the ocean bottom in comparatively recent geologic times to get clues as to how and where oil-bearing sediments were deposited in ancient times.

Aqualung diving techniques were developed for military purposes during World War II. The oil industry is the first to use these techniques for an industrial purpose.

Four geologists and two geological technicians, all of them experienced divers, took part in the expedition. The scientists are members of the staff of the Field Research Laboratories of Magnolia Petroleum Company, an affiliate of Socony Mobil.

Operating from a 65-foot converted shrimp boat, the *Cavalier*, the scientists worked in water up to 65 feet in depth and as many as 45 miles offshore south and east of Galveston, Texas.

The researchers were not hunting for offshore oil in the conventional sense. Offshore drilling locations are presently spotted by essentially the same geological and geophysical methods as are used on dry land. Instead the scientists were using the Continental Shelf as a gigantic field laboratory for their Recent Sediments Study.

Most of the oil fields so far discovered in the world are what geologists call "structural traps"—subsurface closures formed by the subterranean folding and fracturing of rock layers. But some of the biggest oil finds—the great East Texas field, for instance—have been in an entirely different type of trap known as "stratigraphic traps"—sandstone bars or limestone reefs formed in ancient seas by the gradual deposition of sediments.

These reefs and bars—porous rocks surrounded by non-porous rocks—are extremely hard to find by conventional exploration methods. Many of the big oil fields of this type have been found by accident, usually in the course of drilling for structural traps. (Drilling down to locate a structural trap at 6,000 feet in western Canada, Socony Mobil's drilling bits penetrated an oil-bearing sand at 3,500 feet. This previously undetected stratigraphic trap—the Pembina field in Alberta—turned out to be the biggest oil reservoir discovered on the North American continent in 1953.)

One of the main objectives of Socony Mobil's Recent Sediments Study is to develop techniques for predicting the presence and location of limestone reefs and sandstone bars in ancient rock formations.

The researchers think, for instance, that minute differences in the composition of the ancient sediments may provide clues that will point the way to location of stratigraphic traps. They are seeking to test this hypothesis in their study of recent sediments.

Studying the environments in which sediments have been deposited in recent geologic times offers another key to understanding how ancient sediments were formed. To help identify these environments, the scientists collected starfish, snails, shellfish, and other marine animal and plant life found on and under the ocean floor. To get the samples they need for analysis, the scientists used three principal techniques—diving, dredging and coring.

The researchers used a dredge consisting of an ordinary fishing net mounted in a steel mouth with teeth along the underside. It looked, as one of the scientists put it, like a square-headed shark.

Towing the dredge from the stern of the boat, at selected points plotted on a master chart of the exploration area, the researchers brought up 300 pounds or so of sediments and marine life in each haul. They stored samples of the catch in steel cans, carefully labeled by location, for later

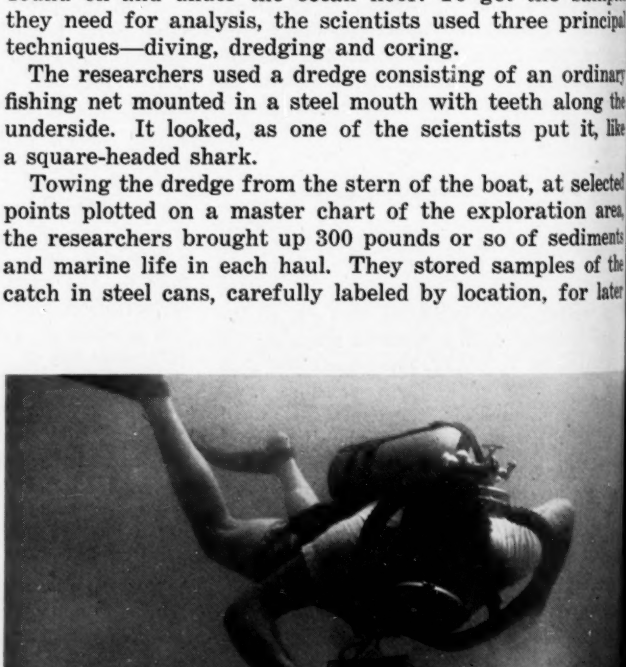


Fig. 1—Camera in watertight case enables researcher to photograph specimen on location.

Fig. 2—Geologists launch a dredge. Sediments scooped from bottom of Gulf of Mexico may yield clues to tomorrow's unfound oil.

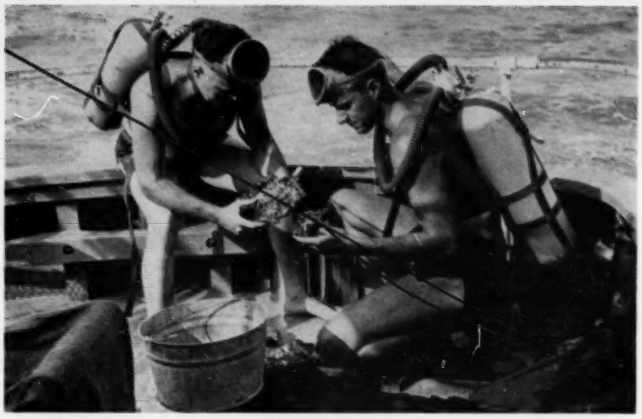


Fig. 3—Socony Mobil skin-divers check specimens collected during underwater exploration almost in shadow of offshore drilling rig.

analysis at the laboratories.

Dredging brought up samples from the surface of the ocean floor. To get samples of older sediments, several feet below the surface, the scientists used a coring barrel—an eight-foot steel pipe enclosing a plastic liner—which was lowered over the side, weighted on top, and plunged into the bottom. Later the plastic tubes containing the cores were pulled out of the pipe and stowed away for study at the laboratories.

Skin-diving made it possible to extend greatly the range of underwater information the scientists could collect. Marine flora and fauna were observed at first hand. Dandelion diggers were used to loosen some of the specimens from the sand and coral bottom. The scientists took photographs with a camera mounted in a watertight case and made underwater notes on their observations by writing with wax pencils on plastic slates strapped to their thighs.

Using a device called a current-meter, the divers calculated the force of underwater currents which dump sediments into the Gulf. The currents were then plotted on the master chart along with other data from the survey.

It was very quiet on the ocean floor. One researcher said he could hear the click of clams shutting their shells as the divers approached.

Occasionally, the quiet was shattered by the sound of dynamite explosions. Another oil company, making a marine seismic survey, was setting off the charges a dozen miles away. On the surface the scientists on the *Cavalier* could see columns of water rise 30 to 40 feet in the air as the charges went off, but they couldn't hear the explosions. The noise could be clearly heard underwater.

The fish were more gregarious than the clams—except for one species that nosedived into the sand at the approach of the divers. Red snapper, angelfish, sheepshead, triggerfish, and many other beautifully-colored tropical fish swam up and nudged the divers' face masks, not at all alarmed by the presence of the intruders.

Two of the geologists are near-sighted. But because of the way light is refracted in the water, or the pressure of the water itself, or for some other reason, neither needed glasses underwater. The two near-sighted geologists could see better on the ocean floor than people with normal vision can see in the open air.

The Socony Mobil scientists prepared for the underwater expedition by spending a week learning to dive in the San Marcos River, at San Marcos, Texas. When they finished the course, all of them were able to pass the diving test the U. S. Navy gives to its frogmen. **END**

4—Thirty-five feet underwater in Gulf of Mexico, skin-diver reaches for sand [illegible] for geology lab's specimen collection.

Fig. 5—With grease pencil and plastic slate, geologist makes underwater notes.

R/E views the books

Solid State Physics—Advances in Research and Applications (Vol. I)

EDITED BY FREDERICK SEITZ AND DAVID TURNBULL

Reviewed by Dr. Frank Herman, Research Physicist, David Sarnoff Research Center, RCA Laboratories

While the study of solids has occupied the attention of physical scientists for many decades, not until recently has solid-state physics emerged as one of the major areas of physical research. During the past few years, many industrial laboratories have initiated solid-state research or have expanded their already existing programs in this field. The stimulus in most cases has been the realization that solid-state devices such as the transistor are destined to play a major role in the technology of the future. However, before solid-state devices can be converted from mere laboratory curiosities into commercially perfected products, a great deal of research and development is required.

From a scientific standpoint, the solid-state area offers almost unlimited opportunity for pioneering exploration. It is hardly surprising, therefore, that many universities and most government laboratories have flourishing solid-state groups.

The expansion of solid-state physics has been so rapid, and the yearly output of scientific and technological papers so enormous, that solid-state scientists are hard pressed to keep abreast of developments in their own areas of specialization, let alone in the field as a whole.

Under such conditions, the individual scientist becomes more and more dependent upon review articles and general surveys for up-to-date information on subjects of marginal interest. With some notable exceptions, most reviews are little more than annotated bibliographies. While these serve the useful purpose of bringing to the attention of the reader the type of work that has been done, such reviews in themselves are not instructive.

There is a pressing need for comprehensive survey articles which are not only reasonably complete and up-to-date, but are also sufficiently detailed to serve as general introductions to the subjects they treat. If we are to judge by the articles contained in the first volume of the *"Solid-State Physics"* series, this series will go a long way toward meeting this need. For here we have a collection of thoughtful articles written by recognized authorities, some of them in the early and highly productive years of their scientific careers, with great pains taken to achieve a high level of expository clarity. Even the non-specialist can hope to read some of these articles from start to finish without finding undue demands on his background knowledge.

At present a series of twelve volumes is planned; the early ones will appear bi-annually, while the later ones will come out at the rate of one a year. In the course of time, the entire solid-state field will be covered, though with varying emphasis. The most active branches will undoubtedly receive major emphasis. To quote from the preface: ". . . three general types of articles are solicited: (1) broad elementary surveys that have particular value in orienting the advanced graduate student or an investigator having little previous knowledge of the subject; (2) broad surveys of fields of advanced research that serve to inform and stimulate the more experienced investigators; (3) more specialized articles describing important new techniques, both experimental and theoretical. It is planned that the authorship be international even though the articles will be written in English".

Listed below are the contributions appearing in this first volume:

"Methods of the One-Electron Theory of Solids" by John R. Reitz.

"Qualitative Analysis of the Cohesion in Metals" by Eugene P. Wigner and Frederick Seitz.

"The Quantum Defect Method" by Frank S. Ham.

"The Theory of Order-Disorder Transitions in Alloys" by T. Muto and Y. Takagi.

"Valence Semiconductors, Germanium and Silicon" by H. Y. Fan.

"Electron Interactions in Metals" by D. Pines.

Reitz attempts to consolidate the various methods that have been developed for calculating the energy levels and the wave functions of electrons in perfect crystals. The more important techniques are described in reasonable detail, and their strong points and drawbacks are carefully delineated. The Wigner and Seitz article endeavors to interpret cohesion in metals in terms of simple physical models. Surprisingly, a great deal can be accomplished in this spirit. Ham's contribution is devoted to a highly specialized subject, and, as such, should appeal to a limited number readers. However, these few readers w find this account not only painstaking thorough, but also highly readable—a r combination. The underlying assumptio receive the major attention, and many a plications are carefully reviewed.

The paper by Muto and Takagi is excellent introduction to a very diffi subject. Considering the breadth of t subject, the article could easily have be twice as long as it is. However, the auth have judiciously chosen their material, a have integrated it into a coherent wh This is the type of article that the ge eral reader will most fully appreciate, a that the expert will read just to see h his point of view compares with that of t authors.

Fan's article is a masterly summary the recent work on silicon and germaniu More than a mere compendium of accum lated information, this paper provides broad outline of recent research activi together with the more significant resul Nobody working in this field can fail read Fan without becoming aware of t many questions that have not yet recei satisfactory answers. This is a healt sign, because the theory of silicon a germanium is still in its infancy, and mu remains to be done.

The final paper, that by Pines, revie one of the most important theoretical d velopments in solid-state physics in rec times, namely, the Bohm-Pines collecti description of electron interactions. Wis Pines avoids involved mathematical di cussions and resorts to simple physi arguments throughout. The flow of ide is both rapid and invigorating.

This volume can be recommended to t interested reader without reservation. T appearance of this series will satisfy a lo standing need.

Academic Press, Inc., New York, N. Y. 4 pages, $10.00.

Chemical Processing and Equipment

PREPARED BY U. S. ATOMIC ENERGY COMMISSION

Unfortunately, the title of this volu does not indicate that it deals exclusive with radioactive materials. Some scientis and engineers interested in the proble of processing and handling irradia chemicals may not discover this valu work as a result. The first 40 or so pa

deal with the techniques of processing reactor fuel elements as developed at the AEC's Idaho Chemical Processing Plant. The major portion of the book is a sort of "New Products" catalog illustrating and describing various instruments developed to handle highly radioactive chemicals in the research laboratory. About 125 devices are described including remote-viewing equipment.

Among the subjects covered in the short first section are: the reactor process itself, plant facilities, process equipment, decontamination of equipment for maintenance, health physics and costs. Photographs, tables and drawings supplement the text.

The equipment section catalog opens with a four-page description of a "hot laboratory" aided by floor-plan drawings.

Originally presented at the Geneva "Atoms-for-Peace" conference last year, the publication of this material will help make atomic energy and applications a growing commercial industry instead of a highly-secret Government reservation.

McGraw-Hill Book Co., Inc., New York, N. Y., 302 pages, $6.00.

Designing for Industry

BY F. C. ASHFORD

Reviewed by Roger Mark Singer, Consultant Industrial Designer

Industrial design is the only profession today that is solely concerned with having the human consumer, with his real and emotional needs, satisfied with the highly engineered, impersonal product he buys from industry. The consultant industrial designer enjoys a unique place in commerce: he is advisor to engineers on design for better human operation and he is advisor to sales on design for wider consumer acceptance. This book deals with the profession as viewed through a British practitioner's eyes.

British industrial design, for the most part, still reflects a certain austerity and coldness as opposed to the more advanced and imaginative American taste. Competition for the home market in Britain exists with fewer firms fighting in any one field. Early model obsolescence is not yet a part of British thinking as it is here, so the drive for new models each year is not firmly established. Because of these factors it is interesting to read a study of British design and compare it to the American profession.

Mr. Ashford covers much of the same material in this book as does Harold Van Doren in his American "*Industrial Design*". It may be chauvinistic to prefer the Van Doren book, but I feel it is far superior and more comprehensive than this British copy. For the practicing designer, there is nothing new in Ashford's book. For the student of design, this book covers the field properly but somewhat hurriedly. However, a manufacturer who has had only a fleeting contact with industrial design might well enjoy this book for its educational import.

The book is well organized. The first portion deals with the "Emotive Aspect" and justifies the position of the designer in the mass-production world. The second section, the "Executive Aspect", covers in five chapters the actual step-by-step development of a product design. The "Material Aspect" goes quickly in two chapters into "all" that a designer need know about production. Here the author fails in touching lightly on one of the most important phases of the field. The final "Commercial Aspect" deals quickly with selling the product. An extensive bibliography accompanies each section. For that top executive who has been approached by industrial designers, this book will be an important night's reading.

Philosophical Library, New York, N. Y. 222 pages, $7.50.

Static and Dynamic Electron Optics

BY P. A. STURROCK

Reviewed by James W. Schwartz
Research Engineer, RCA Laboratories

Seventy-five years have passed since Thomas Edison discovered thermionic emission. Developments in electronics have followed at an ever increasing rate. Very often, it has been difficult or impossible for technical books to keep abreast of the flood of new theories, discoveries and inventions.

Unlike previous books in English, Mr. Sturrock's book on electron optics is almost exclusively theoretical. It appropriately appears as part of the series of Cambridge Monographs on Mechanics and Applied Mathematics. Many of the important subjects of electron optics are included; others, such as electron emission, are conspicuously absent.

Variational formulations of physical problems generally lead to succinct mathematical expressions. Sometimes, such expressions are helpful in deducing general laws or lead more readily to a problem's solution than the classical formulation. Most engineers and research workers, however, think and work almost entirely in terms of the classical approach, the variational method being employed only as a second resort. Mr. Sturrock deals exclusively with the variational methods.

Many of the usual laws of electron optics are derived. A variational treatment of subject matter not available in books on electron optics is included. The sections on deflection aberrations and electron dynamics in asymmetrical fields are particularly noteworthy. Unfortunately, few developments are carried far enough to directly aid the applied worker in electron optics.

The last two chapters discuss the dynamics of particle accelerators. Much of this material cannot be found in electron optics books. The important topics of phase stability, orbital stability, uniform focusing and strong focusing are covered in detail.

Mr. Sturrock's book will be of interest to applied physicists and engineers because of his inclusion of new material. The mathematical physicist will find the extensive application of variational disciplines to electron optics of interest.

Cambridge University Press (Cambridge Monographs on Mechanics and Applied Mathematics series). 240 pages, $5.50.

Reference Texts

Problems and Control of Air-Pollution, edited by Frederick S. Mallette, Reinhold Publishing Corp., New York, N. Y. 272 pages, $7.50.

Authorities in the field of air-pollution control have contributed to this book, a result of the First International Congress on Air Pollution held in March, 1955, sponsored by The American Society of Mechanical Engineers. New material on such problems as the treatment and recovery of sulfur dioxide will be of interest not only to management and technical personnel, but to public health and civic groups.

Basic Mathematics for Science and Engineering by Andres, Miser and Reingold. John Wiley & Sons, Inc., New York, N. Y. 846 pages, $6.75.

Recommended for review purposes for the engineer in industry, this work is a revision of a book first published in 1944 under the title "*Basic Mathematics for Engineers*". The original portion of the book devoted to analytical geometry has been expanded and all the exercises have been replaced.

A-M Detectors and Limiters and Clippers. John F. Rider Publisher, Inc., 480 Canal St., New York 13, N. Y. $1.25 each.

Both of these slim, paper-bound books can be recommended by engineers and research directors to their technical assistants as simple, non-mathematical approaches to understanding fundamental stages in communications receivers. Clear illustrations and direct language are employed.

Production of Heavy Water, edited by George M. Murphy. National Nuclear Energy Series, Div. III, Vol. 4F, Manhattan Project Technical Section. McGraw-Hill Book Co., New York, N. Y. 394 pages, $5.25.

Released for the benefit of chemists, chemical engineers and others concerned with nuclear engineering, the material in this text has not been available before to the general public. Written by a group of specialists, it describes the research and development of large-scale production of water with the heavy hydrogen isotope known as Deuterium, and laboratory and pilot plant studies for separation processes.

Research Reports

Reports in this section may be obtained directly from the Office of Technical Services, U.S. Dept. of Commerce, Washington, D.C., unless another source is stated.

New Weather Forecasting Method

Details of the instrumentation and evaluation of the capabilities of the transosonde concept—a new approach to meteorological data collection—is outlined in this report. Previous studies have indicated the feasibility of a trajectory-type sounding system; consequently, field investigations of the transosonde concept were started with promising results.

This concept was implemented by tracking balloons thousand of miles by means of shore-based high-frequency radio direction-finder stations. The employment of this system for gathering weather data over those regions of the globe where such information is presently lacking will contribute greatly to meteorological analysis and forecasting.

The Transosonde — A New Meteorological Data-Gathering System, *PB 111779, 21 pages, $0.75.*

Low Temperature Metal-to-Metal Adhesive

Development of structural metal bonding adhesive requiring little curing temperature and consisting basically of methacrylic acid and methyl methacrylate is presented step by step in this report. The room-temperature, low-pressure adhesive, designated P-262A, is suitable for the fabrication and field repair of certain airframe structural parts where the use of heating and pressurizing equipment would be impractical or impossible. Also covered in the report are details on preparation of aluminum surfaces to make ready for the bonding operation.

Development of Room-Temperature-Curing Structural Adhesives for Metals, *PB 111764, 89 pages, $2.25*

Shelf Life of Neoprene Coated Nylon Fabrics

Navy research stored nineteen coated fabrics, including four types of neoprene and one Buna-N, for periods of one to over four years. Neoprene coated nylon fabrics were found to have withstood storage very well, with little or no change noted in waterproofness, flexibility, breaking strength, weathering resistance or laundering effects. Small losses were observed in tear strength.

Shelf Life of Neoprene Coated Nylon Fabrics, *PB 111728, 18 pages, $0.75.*

Air Traffic Control

Results of Civil Aeronautics Administration's evaluation of the Rho/Theta transponder system of air traffic control indicate that the system, which includes the S-Band-reply airborne equipment, would be beneficial for terminal-area traffic control except where several S-band radars are in operation. Certain operational and equipment improvements in the airborne transponder, to the antennas, the TR modification kit and the responder are recommended. Two models, one with a reply frequency of 1375 megacycles, the other 2927 megacycles, were evaluated.

Evaluation of the Rho/Theta Transponder System, *PB 111776, $2.25.*

Titanium Studies

Three reports. The first describes one year's research in a program to develop a fundamental understanding of the principles upon which the heat treatability of titanium-base alloys may be founded. A resistometric procedure for determination of transformation kinetics of transforming titanium alloys was developed and results of studies on selected alloys of the titanium-manganese and titanium iron systems are presented.

Structural Changes of Commercial Titanium and Titanium-base Alloys on Heat Treatment, *PB 111767, 123 pages, $3.25.*

The second report is a summary of research done from March 1953 to June 1954 to determine the effects of grain size on the mechanical properties of commercial-purity titanium, on alpha-beta-titanium alloy, and a meta-stable beta-titanium alloy. Mechanical properties studied were tensile, notched tensile, hardness, bend, impact, and fatigue endurance.

The Effect of Grain Size on the Mechanical Properties of Titanium and Its Alloys, *PB 111881, 150 pages, $3.75.*

In the third report unnotched and notched tensile properties are described as a function of testing temperature for a series of titanium-nitrogen and titanium-manganese binary alloys, as well as for the commercial alloy, Ti 140A, and the experimental 3 Mn-complex alloy.

Tensile Properties and Rheotropic Behavior and Titanium Alloys and Molybdenum, *PB 111898, 135 pages, $3.50.*

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